AR AUTO OASIS: AUGMENTED REALITY BASED CAR SHOWCASE

A PROJECT REPORT

Submitted to

Visvesvaraya Technological University

BELAGAVI - 590 018

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Bachelor of Engineering

Department of Computer Science & Engineering

SDM INSTITUTE OF TECHNOLOGY

UJIRE - 574 240

2023-2024

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CERTIFICATE

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Acknowledgement

It is our pleasure to express our heartfelt thanks to Mr. Prasad S R, Assistant Professor, Department of Computer Science and Engineering, for his supervision and guidance which enabled us to understand and develop this project.

We are indebted to Dr. Thyagaraju G S, Head of the Department and Dr. Ashok Kumar T, Principal, for their advice and suggestions at various stages of the work. We also extend our heartfelt gratitude to Mr. Pradeep K Rao, project co-ordinator for their assistance and the management of SDM Institute of Technology, Ujire, for providing us with a good learning environment, library and laboratory facilities.

Lastly, we take this opportunity to offer our regards to all of those who have supported us directly or indirectly in the successful completion of this project work.

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ABSTRACT

The fast-evolving automotive industry faces a crucial need for a more immersive showroom experience to meet proceeding technology and customer expectations. Traditional showrooms, though informative, are falling short. They lack engagement and personalization, limiting buyers to physical viewings, hindering accessibility, and often providing inconsistent information through reliance on sales representatives. Accessibility to physical showrooms may be restricted for various reasons, such as location, time constraints, or unavailability of interested car which can hinder potential buyers' ability to visit showrooms. The augmented car showcase project represents a cutting-edge solution that seeks to redefine the manner in which consumers engage with and gain insights into automobiles. This project strives to deliver a dynamic and interactive car-buying encounter, one that empowers consumers with profound insights into product details. AR enables users to seamlessly view and virtually engage with car models within the context of their physical surroundings. This ensures more engaging and informative car shopping experience. AR provides comprehensive information about cars specifications, technologies, safety features and pricing aiding users in making informed decisions. Its potential to disrupt and modernize the traditional automotive retail marks it as a promising and impactful development in consumer commerce. The Augmented Car Showcase project does not solely serve consumers; it also represents a transformative sales and marketing tool for automobile manufacturers and dealerships alike. By optimizing the efficiency of the sales process, reducing the necessity for extensive physical inventory, and unlocking fresh avenues for inventive marketing endeavors, this technology offers unprecedented advantages to industry stakeholders.

Tabel Of Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Project Introduction

In the ever-evolving landscape of technology, Augmented Reality (AR) stands as a transformative force, bridging the gap between the digital and physical worlds. AR enriches our perception of reality by overlaying computer-generated information onto our immediate surroundings, enhancing the way we interact with and perceive the world around us. At its core, AR expands the boundaries of our sensory experiences, offering a dynamic blend of virtual and real elements. Unlike Virtual Reality (VR), which immerses users in entirely virtual environments, AR enhances our existing reality by seamlessly integrating digital content into our everyday lives. This integration is often facilitated through devices like smartphones, tablets, smart glasses, and AR-specific hardware. In the dynamic landscape of automotive retail, the Augmented Reality (AR) Car Showcase emerges as a groundbreaking fusion of cutting-edge expertise and the artistry of automobile design. This innovative platform redefines the conventional car showroom experience by seamlessly integrating the virtual and physical realms, offering customers an immersive journey into the world of their dream vehicles. The AR Car Showcase leverages augmented reality technology to transform traditional showrooms into interactive hubs of exploration and customization. Imagine stepping into a space where your favorite cars come to life, not just as physical entities but as dynamic, information-rich digital experiences. This is the essence of the AR Car Showcase, where the limits between the tangible and the virtual blur, creating a captivating environment for automotive enthusiasts. AR has notably enriched our digital-physical interactions, elevating conversational AI by seamlessly merging virtual and real worlds. In AR-equipped car showrooms, customers embark on dynamic journeys with their dream cars. This allows users to virtually inspect, explore, and test drive their dream vehicles from their own space, creating an enchanting portal where car fantasies transform into reality, and the path to vehicle ownership becomes an immersive adventure. Augmented reality, a technology that overlays digital evidence onto the real world, has gained prominence across various industries, and the automotive segment is no exception.

1.2 Problem Description

As technology advances, the automotive industry explores innovative ways to engage customers and enhance the car-buying experience. One such solution is the use of Augmented Reality (AR) in car showcases, where potential buyers can interact with virtual representations of vehicles in real-world environments. However, implementing an AR car showcase comes with its set of challenges. In a traditional showroom, customers can physically touch, open doors, and sit inside vehicles. AR car showcases may limit these tactile experiences, potentially impacting the customer's ability to fully evaluate the car's features and comfort. Achieving high visual fidelity and realism in AR representations of cars can be challenging. The virtual models must accurately reflect the details of the actual vehicles, including colour, texture, and fine features, to provide a convincing and immersive experience.

Chapter 2

Literature Review

2.1 Literature Survey

In the paper titled “Augmented Reality in Architecture and Construction Education”[1] by Aso Hajirasouli and Saeed Banihashemi published this paper in the year 2022, addresses the growing influence of augmented reality (AR) in revolutionizing architecture and construction industries while recognizing a significant gap in its integration within educational contexts. Through an in-depth exploration, the authors propose two innovative pedagogical approaches to bridge this divide. Firstly, they advocate for a Constructivist methodology, emphasizing active learning where students engage with AR tools to interactively explore architectural designs and construction processes. This approach empowers students to construct their understanding by immersing themselves in practical experiences, fostering critical thinking and problem-solving skills essential for professional success. Secondly, the authors introduce the concept of Experiential Learning through Immersive AR Simulations, leveraging AR technology to create realistic virtual environments that replicate real-world architectural challenges. These simulations provide students with hands-on experiences, allowing them to navigate complex scenarios and develop practical skills in a risk-free environment.

In the paper titled “3D Modelling of Virtual Built Environment using Digital Tools”[2] by Kiburus Fortress Case Study," authored by Ihor Tytarenko, Iva Pavlenk, and Iryan Dreval, and published in 2023, offers a comprehensive examination of the methodologies and digital tools essential for reconstructing historical and cultural landmarks, with a specific focus on the Kiburus Fortress. It begins by emphasizing the profound importance of preserving such sites, recognizing their role in maintaining cultural identity and facilitating historical understanding. The authors then detail the meticulous process of creating a 3D model of the fortress, starting with the initial design phase using AutoCAD and SketchUp. This stage demands meticulous attention to detail to accurately capture the architectural elements and layout of the fortress. As the paper progresses, it discusses subsequent stages of rendering and final processing, where Quixel software is employed to elevate the visual fidelity of the model. Through advanced rendering techniques like texture mapping and lighting effects, the authors aim to craft a lifelike representation of the fortress, ensuring authenticity and realism in the virtual reconstruction.

In the paper titled “3D Technologies for Intangible Cultural Heritage Preservation”[3] by Maria Skuhewska-Paszkowska, Marek Milosz, and Pawel Powroznik, and published in 2022, provides a comprehensive review of the utilization of 3D digital technologies in preserving intangible cultural heritage (ICH). The authors aim to assess the current state of this field by identifying prevalent themes, discussing the specific 3D technologies employed, mapping research center locations, and categorizing types of research conducted. Through their analysis, they highlight that among the various 3D technologies used, 3D visualization and motion capture systems are commonly employed for ICH preservation. These technologies play essential roles in capturing and representing intangible cultural heritage elements digitally, facilitating documentation, analysis, and dissemination efforts. The paper likely offers insights into the specific applications, benefits, and challenges associated with each technology, providing a nuanced understanding of their effectiveness in preserving ICH. Furthermore, it may discuss the global distribution of research centers engaged in this work and categorize research types to offer a comprehensive overview of approaches and methodologies in the field.

The paper titled “The Research of 3D Modeling between Visual & Creativity”[4] authored by Dahlan Abdul Ghani, Muhammad Naim Bin Supian, and Luqman Zulhilmi Bin Abdul 'Alim, and published in 2019, presents an expansive exploration of the multifaceted domain of 3D modeling and character design. Through a meticulous examination, the authors not only delineate the fundamental principles underlying 3D modeling but also delve into its practical applications across diverse industries, with a particular focus on its development within Malaysia's burgeoning animation sector. By categorizing 3D modelling into wireframe, surface, and solid modeling, the paper provides a structured framework for understanding the intricacies of different modeling techniques. Additionally, the authors meticulously dissect various methodologies employed in 3D modeling, including polygonal modeling, curve modeling, and digital sculpting, elucidating how each method contributes to the creation of visually compelling and immersive digital content. Furthermore, the paper underscores the symbiotic relationship between technology and creativity, emphasizing the pivotal role of visual aesthetics in the design process. By contextualizing their discourse within the Malaysian animation industry, the authors offer invaluable insights into the localized adoption and advancement of 3D modelling techniques, shedding light on industry trends and emerging practices. This localized perspective not only enriches the discussion but also underscores the global significance of Malaysia's contribution to the digital content creation.

In the paper titled “The image-based 3D modeling” [5] The author Fabio Remondino, Sabry El-Hakim published this paper in the year 2006, represents a seminal contribution to the field of 3D modeling by providing a thorough examination of the techniques and methodologies involved in generating 3D models from terrestrial images. Through a meticulous review, the authors offer a comprehensive understanding of the entire process, encompassing data acquisition, calibration, orientation, visualization, and 3D reconstruction. By dissecting each stage of the pipeline, the paper elucidates the challenges inherent in image-based modeling and proposes practical solutions to address them. Notably, the authors underscore the versatility and efficiency of image-based modeling, highlighting its advantages in terms of completeness, cost-effectiveness, portability, and flexibility compared to alternative methods. Furthermore, by contextualizing their discussion within the broader landscape of 3D modeling, the paper serves as a guide for researchers, practitioners, and industry professionals seeking to leverage terrestrial image data for creating accurate and detailed 3D models. Its comprehensive analysis and practical insights not only contribute to advancing the state-of-the-art in image-based 3D modeling but also lay the groundwork for future innovations in this dynamic field. Overall, "The Image-based 3D Modeling" stands as a seminal work that continues to shape our understanding and approach to generating 3D models from terrestrial images.

In the paper titled “Dynamic Depth-of-Field Projection Mapping Method Based on a Variable Focus Lens and Visual Feedback” [6] by Lihui Wang, Satoshi Tabata, Hongjin Xu, Yunpu Hu, Yoshihiro Watanabe, and Masatoshi Ishikawa presents an innovative approach to high-speed projection mapping tailored for interactive display technology within augmented reality (AR) systems. Central to the system's functionality is a dynamic focal tracking mechanism driven by a variable focus lens, which works in tandem with a high-speed camera and projector setup. This configuration enables real-time adjustments of focal length and the continual updating of projection data, leveraging depth and rotation feedback to ensure precise and well-focused projections, even on moving 3D objects. By integrating visual feedback mechanisms with dynamic depth-of-field projection mapping, the system enables immersive and interactive AR experiences, enhancing the realism and effectiveness of virtual content overlaid onto physical environments. This innovative approach not only expands the capabilities of projection mapping technology but also holds promising implications for various applications, including entertainment, education, and industrial use cases. Through its practical implementation and demonstrated effectiveness, the paper contributes to the advancement of AR devices.

In the paper titled “An Image Augmentation Method Based on Limited Samples for Object Tracking Based on Mobile Platform” [7] by Zihao Wang, Sen Yang, Mengji Shi, and Kaiyu Qin presents a pioneering approach to address the challenges of object tracking on mobile platforms with limited sample data. Mobile platforms often face constraints such as a scarcity of effective samples, platform jitter, and relative rotation between the camera and the tracked object, which can hinder accurate object detection. To mitigate these issues, the authors propose an innovative image augmentation model that leverages geometric projection transformation, multi-directional overlay blurring, and random background filling techniques. These methods enhance the generalization of available sample data, making the tracking system more robust to variations in object appearance and environmental conditions. Moreover, traditional augmentation methods are integrated into the model to further diversify the dataset, resulting in an adjustable probability factor model capable of simulating a wide range of scenarios. Through rigorous testing with state-of-the-art object detection models like SSD, YOLOv3, YOLOv4, and YOLO, the effectiveness of the proposed approach is demonstrated, showing a significant minimum improvement of 10% in detection accuracy, particularly for planar objects. This paper not only addresses critical limitations in mobile-based object tracking but also offers a practical solution to enhance detection performance, paving the way for more reliable and efficient tracking systems in real-world mobile applications.

In the paper titled “An Efficient Approach for 2D to 3D Image Conversion Using Fuzzy C-Means Segmentation”[8] by M. Sheik Mansoor and Dr.M. Mohamed Sathik proposes a method for 2D-to-3D image conversion based on edge information. The approach involves converting the input RGB image into HSV colour space, then into a grayscale image. Fuzzy C-Means Segmentation is employed to segment the image, and depth values are assigned to each segment using an initial depth hypothesis. The paper addresses blocky artifacts with cross bilateral filtering and obtains multi-view images through Depth Image-Based Rendering (DIBR). The method aims to create visually comfortable 3D images without artifacts, enhancing display quality. Performance metrics such as PSNR, SSIM, MSE, and RMSE are used to analyse the proposed method, demonstrating its superior performance compared to existing methods in experimental results. The paper highlights the significance of 2D to 3D conversion for 3DTV development and addresses the challenges and opportunities in the field.

In the paper titled “View-dependent 3D Projection using Depth-Image-based Head Tracking”[9] by Jens Garstka and Gabriele Peters presents a pioneering approach to seamlessly integrating virtual content into physical environments, bypassing the need for cumbersome hardware or expensive display devices. Central to the system's functionality is the utilization of affordable depth camera systems, which effectively capture and track the viewer's head movements in real-time. This enables precise adjustments to the projected content based on the viewer's perspective, resulting in a dynamic and immersive augmented reality experience. The system's view-dependent 3D projection technique allows virtual scenes to be accurately projected onto flat surfaces, creating a seamless blend of virtual and physical elements. Notably, the system prioritizes affordability and unobtrusiveness by employing low-cost depth cameras for head tracking, ensuring accessibility for a wide range of users. By dynamically adapting the projection in response to the viewer's movements, the system enables users to explore the virtual content from different angles simply by moving around the physical space, enhancing engagement and interaction. Additionally, the paper provides a comprehensive discussion of prior methods in the related work section, offering valuable insights into existing approaches and their limitations. This paper represents a significant advancement in augmented reality technology, offering a practical and cost-effective solution for creating immersive 3D visualizations with broad applications across industries such as gaming, education, and interactive media.

In the paper titled “Automatic Learning based 2D-to-3D Image Conversion”[10] by Victoria M. Baretto discusses the challenge of converting 2D content to 3D due to the limited availability of 3D content. The paper proposes two distinct methodologies for automatic 2D-to-3D conversion, each designed to streamline the process and address the scarcity of native 3D resources. The first approach involves employing regression techniques to learn a point mapping from local image attributes, enabling the generation of depth information for the 2D content. Conversely, the second method focuses on globally estimating the entire depth map by leveraging a repository of existing 3D images and applying a nearest-neighbour regression strategy. These machine learning-inspired methods offer promising avenues for automating the conversion process, potentially revolutionizing the creation of 3D content from 2D sources. The paper meticulously evaluates the qualitative performance, computational efficiency, and potential limitations of these approaches, providing valuable insights into their practical viability and effectiveness.

2.2 Comparative Analysis of the Related Work

The table 2.1 discusses the comparative analysis of the current systems in light of the suggested proposal.

Table 2.1 Comparative Analysis

SI.No	**Author(s)**	**Algorithms/Techniques**	**Performance measures**
1.	Victoria M.Baretto	Semi-automation automatic 2D-to-3D Conversion	Accuracy (98%)
2.	Jems hastka and Gabriele Peters	Depth camera system,wii Remote for head tracking in 3D Projection.	Accuracy (90.88%)
3.	M.sheik nasoor,Dr.m.mohammed satik	Depth-image Based rendering 3DTV	Accuracy (90.12%)
4.	Aso Hajrasoul,saeed Banihashmi	Immersive AR simulation ,Object tracking framework RMSE	Accuracy (89.23%)
5.	Kibusus fortess	Quixel Visualization,3D visualization for augmented reality	Accuracy (90.4%)
6.	Pauul powroznik,mask,Milosz	3D Visualization, Tractive motion.	Accuracy (94.6%)
7.	Dahhan abdul Ghani,Abdul Alim	Motion capture system,Virtual reality.	Accuracy (89.44%)
8.	M. Sheik Mansoor and Dr. M. Mohamed Sathik	Fuzzy C-Means Segmentation. Depth Image-Based Rendering (DIBR).	Accuracy (96.3%)
9.	Jens Garstka and Gabriele Peters	Depth camera to track head movement, time-of-flight cameras.	Accuracy (91.8%)
10.	Victoria M. Baretto	2D-to-3D conversion: based on learning a point mapping from local image attributes using regression.	Accuracy (93.19%)

2.3 Summary

These were the research papers that we studied to gain a better understanding of the problem. Augmented reality algorithms have been implemented to create AR projection in the real time world within user space. Different Augmented Reality techniques are available based on our project we chose marker-based tracking for augmented reality projection in the project that provides project based on the pre-defined marker. We chose SLAM, Depth sensing algorithm and real time rendering algorithms to implement our project.

Chapter 3

Problem Formulation

3.1 Problem Statement

Despite the significant strides made in the automotive sector, the conventional showroom experience remains a bottleneck in the customer's journey towards purchasing a car. Traditional showrooms often fail to captivate customers and fully convey the features, design, and functionality of a vehicle. Potential buyers are left with limited perspectives, relying on brochures, static displays, and verbal explanations from sales representatives. This inadequacy results in a gap between customer expectations and the information they receive, leading to a suboptimal decision-making process. The fast-evolving automotive industry faces a crucial need for a more immersive showroom experience to meet advancing technology and customer expectations. Traditional showrooms, though informative, are falling short. A solution lies in AR-enhanced showrooms with integrated voice assistants that transform how customers explore vehicles. Traditional showrooms lack engagement and personalization, limiting buyers to physical viewings, hindering accessibility, and often providing inconsistent information through reliance on sales representatives. Accessibility to physical showrooms may be restricted for various reasons, such as location, time constraints, or unavailability of interested car which can hinder potential buyers' ability to visit showrooms. Indeed, the automotive industry is undergoing rapid changes, and there is a growing recognition of the limitations of traditional showrooms in meeting the evolving needs of customers. Augmented Reality (AR) and integrated voice assistants present an exciting opportunity to revolutionize the showroom experience.

3.2 Objectives of the Present Study

The objectives of the proposed project are as follows:

1. 1.To create an immersive user experience with augmented reality to create a sense of virtual car showroom.
2. To provide a user-friendly platform for streamlined access to car information, financial assistance, test drive scheduling and real-time notifications for users to stay updated on new car releases and financing options.
3. To provide an opportunity to customize the car based on user’s interest.

3.3 Summary

The best solution for experiencing augmented reality experience is by using marker-less tracking techniques. The algorithms like SLAM, Depth sensing enables effective projection of required image in Augmented reality. Developing an AR enabled car showcase enables user to save time and view their desired car in their environment enhancing the way user interacts with the car and providing a virtual experience than physical showrooms. By embracing this innovative technology, car manufacturers and dealerships aim to provide customers with a transformative and personalized car-buying experience, ushering in a new era where augmented reality becomes an integral part of the journey from showroom to ownership. The subsequent exploration of the challenges and potential solutions in implementing such a paradigm shift will shed light on the complexities and opportunities that lie ahead in the augmented reality-driven future of automotive retail.

Chapter 4

Requirements and Methodology

4.1 Hardware Requirements

The hardware requirements for the proposed project are depicted in Table 4.1.

Table 4.1: Hardware requirements

Sl. No	Hardware/Equipment	Specification
1.	Graphics Card	Nvidia GeForce GTX 1660 Super, AMD Radeon RX 5600 XT
2.	RAM	4GB or above

4.2 Software Requirements

The software requirements for the proposed project are depicted in Table 4.2.

Table 4.2: Software requirements

Sl. No	Software	Specification
1.	PHP	7.x or higher
2.	MySQL	5.7 or higher
2.	Apache	2.4x or higher
3.	Blender	3.0 and above
4.	Unity3D	Unity XR toolkit

4.3 Methodology Used

STEP 1: Image collecting and storing

- Collect the images of the car.
- Develop data collection scripts and tools for car information, design 3D models, and AR models.
- Choose and set up a suitable database type and design a schema.

STEP 2: Use of algorithms

- Choose an android-based AR framework (AR Core and AR Foundation) and integrate it for AR rendering.
- SLAM (Simultaneous Localization and Mapping), Depth Map Creation and Real-Time Rendering for augmenting the car.

STEP 3: System Design and Development

- Design the user interface (UI) using HTML, CSS, and JavaScript.
- Develop the backend logic using PHP and Unity3D for data processing.

STEP 4: Performance Analysis and Optimization

- Conduct thorough testing for bug identification and cross-browser compatibility.
- Fine-tune the application for speed and responsiveness, implementing caching, compression, and other optimization techniques.

Chapter 5

System Design

5.1 Architecture of the Proposed System

Figure 5.1 shows the architecture of the proposed system. The first step is to create user interface and check user authentication then the dashboard appears with list of services like financial assist voice assistant test drive and comparisons upon choosing the desired car, 3d images created using blender are displayed with detailed information of car which is stored in database and upon clicking view in space option augmented projection of car is obtained.

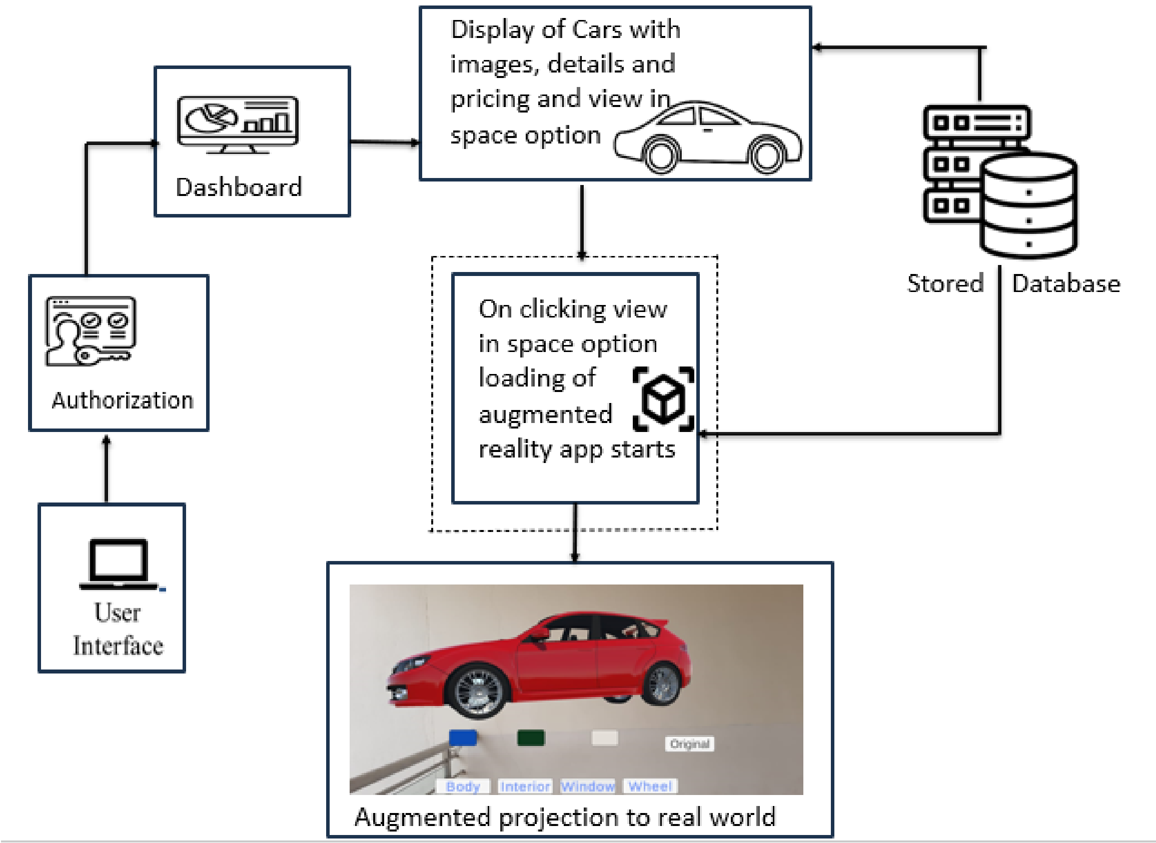


Figure 5.1: Architecture of the proposed system

User is first made available with the user interface. User needs to login using the email and password and authentication of user is done if he is the authorized user access is granted if not access is denied. The dashboard consists of pages like home financial assistance test drive and contact which upon clicking navigates to the respective pages. User can avail the required services based on their interest and need.

5.2 System Flowchart

A system flowchart is a way of depicting how data flows in a system and how decisions are made to control events. Figure 5.2 depicts the system flowchart.

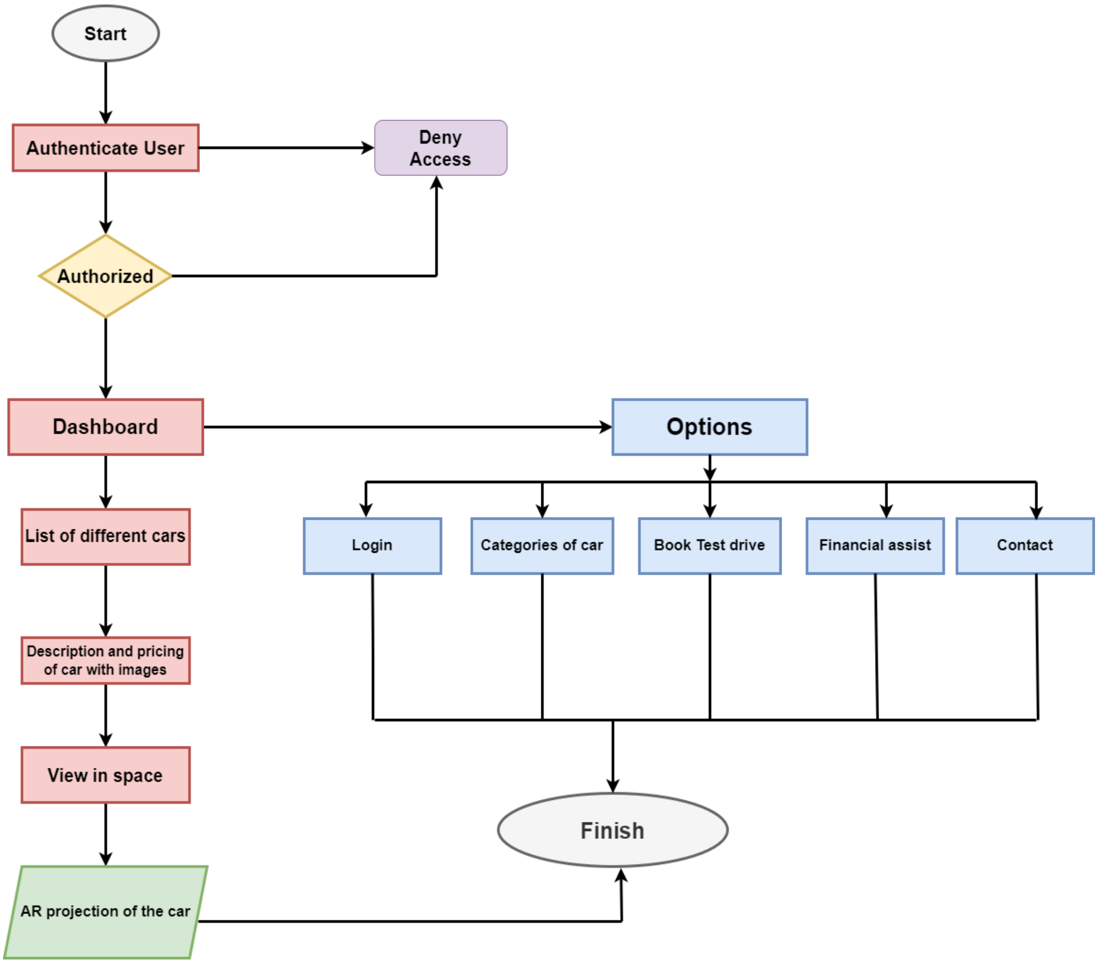


Figure 5.2: System Flowchart

The raw dataset must be loaded, cleaned, and preprocessed. Using blender 3D images are created and displayed with detailed information. Dashboard appears with list of services and view in space creates AR projection of the car is obtained in the user environment. The system flow chart shows how the flow of the entire system goes. After entering into the user interface authentication of the user will be carried on confirming that the user is authorized one access will be granted if not access is denied. Later the user is directed towards the dashboard that contains different services like voice assistance, financial help, test drive and comparison. List of cars will be displayed on the dashboard clicking on the desired car leads to 3D viewing and detailed description of the selected car. View in your space provides an option to view the car in the augmented projection in the user space.

5.3 Algorithms

The following algorithms are used in our project.

1) SLAM (Simultaneous Localization and Mapping)
2) Depth Map Creation
3) Real-Time Rendering

5.3.1 SLAM (Simultaneous Localization and Mapping)

This algorithm is used for AR devices to understand their position and map environment in real-time. SLAM is a technique that allows a device to create a map of its environment in real-time while simultaneously tracking its own position within that environment. SLAM systems use a combination of sensors (such as cameras, accelerometers, gyroscopes) to gather data about the surroundings. The algorithm processes this data to build a map of the environment and estimate the device's position within it. Simultaneous Localization and Mapping (SLAM) is a crucial algorithm in the field of robotics and computer vision that enables a mobile system to simultaneously create a map of its environment and determine its own location within that map. This process is essential for autonomous navigation and exploration in environments where external localization information, such as GPS, is either unreliable or unavailable.

SLAM algorithms typically involve a combination of sensor data, such as visual information from cameras, depth data from depth sensors like LiDAR or radar, and odometry information from wheel encoders. The goal is to fuse this data to construct a consistent and accurate representation of the surroundings, while also estimating the pose (position and orientation) of the robot within this map. The SLAM process can be broadly divided into two main components: the mapping module and the localization module.

Mapping Module: Feature Extraction: In the mapping phase, the algorithm extracts distinctive features from sensor data. These features could include key points in visual data or prominent landmarks in LiDAR scans.

Data Association: The algorithm associates extracted features across multiple sensor measurements to understand which features correspond to the same real-world entity. This involves solving the data association problem, matching observed features with features in the map.

Map Update: Once associations are established, the algorithm updates the map with newly observed features. This step involves refining the positions of existing map features and adding new ones.

Loop Closure: To enhance map consistency and correct accumulated errors, SLAM algorithms often incorporate loop closure detection. This involves identifying when the robot revisits a previously visited location and closing the loop in the map.

Localization Module: Using sensor data and the existing map, the SLAM algorithm continuously estimates the pose of the robot in real-time. This involves determining the robot's position and orientation within the environment.

Kalman Filters and Particle Filters: Many SLAM algorithms use probabilistic approaches such as Kalman filters or particle filters to estimate the robot's pose. These filters help manage uncertainty and improve the accuracy of pose estimates.

Simultaneous Estimation: The key challenge in SLAM is to estimate the robot's pose and update the map simultaneously. This requires managing the uncertainty in both the robot's pose and the map features.

SLAM algorithms can be categorized as either visual SLAM (VSLAM), which primarily relies on visual sensor data, or laser SLAM, which utilizes laser scanners like LiDAR. Hybrid methods that combine multiple sensor modalities are also common to leverage the strengths of different sensors. In summary, SLAM is a fundamental technology enabling autonomous systems to navigate and understand their surroundings. It has applications in various fields, including robotics, self-driving cars, and augmented reality. The continuous development of SLAM algorithms contributes to the advancement of autonomous systems, making them more reliable and adaptable in real-world environments.

SLAM algorithms have revolutionized various industries by enabling machines to perceive and interact with their environment autonomously. In robotics, SLAM facilitates the navigation of unmanned vehicles in complex, dynamic environments, such as warehouses or outdoor terrains, where GPS signals may be unreliable. Moreover, in the realm of self-driving cars, SLAM plays a pivotal role in creating detailed maps of urban landscapes and accurately localizing vehicles within them, enhancing safety and efficiency on the roads. Additionally, in the domain of augmented reality (AR), SLAM empowers devices to overlay virtual elements seamlessly onto the real world, offering immersive and interactive experiences for users.

5.3.2 Depth Map Creation

This algorithm is used for depth sensing. Capture depth information of the real-world scene for more accurate object placement and occlusion. Creating a depth map involves estimating the distance of objects in a scene from the camera. Depth maps are useful in various applications, including 3D reconstruction, augmented reality, and computer vision. Here are the general steps to create a depth map. Depth sensing algorithms play a crucial role in computer vision and robotics by enabling machines to perceive the three-dimensional structure of the surrounding environment.

One common technology for depth sensing is Time-of-Flight (ToF) cameras. ToF cameras emit light signals and measure the time it takes for the signals to return after reflecting off objects. This information is then used to calculate the distance between the sensor and the object, creating a depth map. Another widely used depth sensing technology is stereo vision, which relies on the triangulation principle using two or more cameras. Basic Depth Sensing Techniques:

Stereo Matching: In stereo vision, two or more cameras capture the same scene from slightly different viewpoints. Corresponding points in the left and right images are identified, and disparities (horizontal pixel shifts) are calculated. Using the known baseline distance between the cameras and the disparity information, the depth of each pixel can be computed.

Structured Light: A structured light system projects a known pattern onto the scene, such as a grid or set of lines. The deformed pattern is captured by a camera, and the depth information is inferred from the distortion of the projected pattern. This technique is commonly used in 3D scanners and depth-sensing cameras.

Time-of-Flight (ToF): ToF cameras emit light pulses and measure the time it takes for the light to travel to the object and back. The distance to the object is calculated based on the speed of light and the time-of-flight of the emitted pulse. ToF cameras can provide real-time depth information and are often used in applications like gesture recognition and robotics.

Depth from Focus: This technique utilizes the concept that objects at different distances will bring different parts of an image into focus.

By analyzing the sharpness of the image at various depths, the algorithm can estimate the depth of the scene.

Accuracy and Precision: Achieving accurate depth measurements is crucial for applications like robotics and autonomous vehicles. Calibration and careful sensor design are essential to minimize errors.

Noise and Artifacts: Depth sensing systems can be susceptible to noise and artifacts, leading to inaccuracies in depth maps. Advanced filtering techniques are often employed to address these issues.

Dynamic Environments: Depth sensing in dynamic environments with moving objects or changing lighting conditions can be challenging. Algorithms must adapt to handle such variations in real-time.

Computational Complexity: Some depth sensing algorithms involve complex computations, which may pose challenges for real-time applications. Efficient implementation and hardware acceleration are often used to address computational demands.

In conclusion, depth sensing algorithms are fundamental in providing machines with a perception of the spatial structure of their surroundings. As technology advances, depth sensing continues to play a pivotal role in enhancing the capabilities of autonomous systems and computer vision applications. Researchers and engineers are continually exploring new techniques and technologies to improve the accuracy, speed, and robustness of depth sensing algorithms for a wide range of applications.

5.3.3 Real-Time Rendering

It mainly used to identify flat surfaces (horizontal or vertical planes) for accurate placement of virtual objects. Plane detection algorithms, often integrated with SLAM, are used to identify surfaces in the environment. Real-time rendering refers to the process of generating and displaying images or animations at interactive rates, typically at or above 30 frames per second (FPS). This is crucial for applications where low latency and a high level of interactivity are essential, such as video games, virtual reality, augmented reality, and simulations. Real-time rendering involves various techniques and technologies to achieve fast and responsive visual output. Real-time rendering algorithms are essential for generating and displaying computer graphics in a responsive manner, typically at interactive frame rates. These algorithms are crucial in applications like video games, virtual reality, simulations, and other interactive graphics environments.

Shading and Lighting: Shading models simulate the interaction of light with surfaces to produce realistic lighting effects. Real-time rendering often employs simplified models, such as the Phong or Blinn-Phong reflection models, to calculate the color of each pixel. Light sources, shadows, and reflections are crucial for realistic scenes. Simplified shadow mapping and screen-space reflections are common real-time techniques for incorporating these effects.

Level of Detail (LOD): To maintain real-time performance, LOD techniques dynamically adjust the complexity of objects based on their distance from the camera. LOD can involve simplifying geometry, reducing texture resolution, or using impostors (pre-rendered representations) for distant objects.

Real-time rendering algorithms are continuously evolving to meet the demands of increasingly complex virtual environments while maintaining high frame rates and responsiveness. Techniques such as advanced culling methods, like occlusion culling and frustum culling, help optimize rendering by excluding objects or portions of the scene that are not visible to the camera. This selective rendering approach significantly reduces computational overhead, allowing real-time rendering systems to focus processing power on rendering only the essential elements within the user's field of view. Moreover, optimizations like batch rendering and instancing enable efficient rendering of multiple similar objects by minimizing the number of draw calls and reducing GPU overhead, further enhancing performance in real-time rendering applications.

In addition to optimizing rendering performance, real-time rendering algorithms also prioritize visual quality to create immersive and engaging experiences for users. Techniques such as post-processing effects, including motion blur, depth of field, and anti-aliasing, enhance the realism and visual fidelity of rendered scenes in real time. Furthermore, advancements in physically-based rendering (PBR) techniques allow for more accurate simulation of materials and lighting, resulting in visually stunning and lifelike virtual environments. As real-time rendering technology continues to advance, it opens up new possibilities for interactive storytelling, digital art, architectural visualization, and other creative endeavors, pushing the boundaries of what is possible in real-time computer graphics.

Chapter 6

Implementation

6.1 Code for Test Drive

```
<?php

include "db.php";

if (isset($_POST['submit'])) {

    $name = mysqli_real_escape_string($con, $_POST['name']);

    $email = mysqli_real_escape_string($con, $_POST['email']);

    $phone = mysqli_real_escape_string($con, $_POST['phone']);

    $preferred_date = mysqli_real_escape_string($con, $_POST['preferred_date']);

    $preferred_time = mysqli_real_escape_string($con, $_POST['preferred_time']);

    $message = mysqli_real_escape_string($con, $_POST['message']);    $query = "INSERT
INTO test_drive_requests (name, email, phone, preferred_date, preferred_time, message)
VALUES ('$name', '$email', '$phone', '$preferred_date', '$preferred_time', '$message')";

    $result = mysqli_query($con, $query);

    if ($result) {

        echo "<script>alert('Test drive request submitted successfully. We will contact you
shortly.')</script>";

    } else {

        // Error message

        echo "<script>alert('Failed to submit test drive request. Please try again.')</script>";

    } }
```

6.2 Color Changing of Car code

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;

public class changecolor : MonoBehaviour

{

    public Color[] colors;

    public Renderer[] mats;


    public void Green()

    {

        for(int i=0;i<mats.Length;i++)

        mats[i].material.color= colors[0];

    }

    public void Blue()

    {   for(int i=0;i<mats.Length;i++)

        mats[i].material.color= colors[1];}

    public void White()

    {

        for(int i=0;i<mats.Length;i++)

        mats[i].material.color= colors[2];

    }

    public void red()

    {

        for(int i=0;i<mats.Length;i++)

        mats[i].material.color= colors[3];

    } }
```

6.3 Toggling code

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;

public class meshtoggler : MonoBehaviour

{

   public GameObject CarObject;

    private bool isActive=true;

    public void Toggle()

    {

        if(isActive)

        {

            CarObject.SetActive(false);

            isActive=false;

        }

        else{

            CarObject.SetActive(true);

            isActive=true;

        }

}

}
```

6.4 Rotation Code

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;

public class rotationcontroller : MonoBehaviour

{

    public Vector3 rotationVector;

    private void Update()

    {

             transform.Rotate(rotationVector*Time.deltaTime);

    }

}
```

6.5 Code of php for showing the successful payment done by user.

```
<?php
session_start();

if(!isset($_SESSION["uid"])){

            header("location:index.php");

}

if (isset($_GET["st"])) {

# code...

            $trx_id = $_GET["tx"];

             $p_st = $_GET["st"];
```

```
$amt = $_GET["amt"];

$cc = $_GET["cc"];

$cm_user_id = $_GET["cm"];

$c_amt = $_COOKIE["ta"];

if ($p_st == "Completed") {

include_once("db.php");

$sql = "SELECT p_id,qty FROM cart WHERE user_id = '$cm_user_id'";

$query = mysqli_query($con,$sql);

if (mysqli_num_rows($query) > 0) {

# code...

while ($row=mysqli_fetch_array($query)) {

$product_id[] = $row["p_id"];

$qty[] = $row["qty"];

}

for ($i=0; $i < count($product_id); $i++) {

$sql = "INSERT INTO orders
(user_id,product_id,qty,trx_id,p_status) VALUES
('$cm_user_id','".$product_id[$i]."','".$qty[$i]."','$trx_id','$p_st')";

mysqli_query($con,$sql);

}

$sql = "DELETE FROM cart WHERE user_id = '$cm_user_id'";

if (mysqli_query($con,$sql)) {

?>
```

Chapter 7

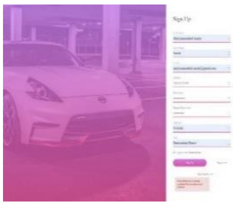
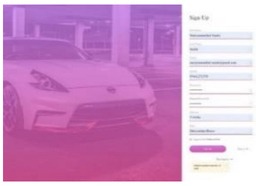
System Testing, Results and Discussion

7.1 System Testing

System testing is a critical phase where the entire software is tested as a whole. It validates that the system meets specified requirements and functions correctly in its intended environment. This phase often includes functional, performance, and security testing. System testing ensures seamless integration of all components and identifies any defects or inconsistencies before deployment. It aims to provide stakeholders with confidence in the system's reliability and suitability for use.

Table 7.1: Unit test cases

Test case number	Input	Stage	Expected behavior	Observed behavior	status P=pass F=Fail
1	Register/Sign Up with valid user credentials. 	User Authentication	User successfully logged in	User successfully logged in	P
2	View car in AR mode 	AR Car Visualization	Virtual car model correctly displayed in AR	Virtual car model correctly displayed in AR	P
3	Apply for financing assistance 	Financial Assistance	Financing application submitted successfully	Financing application submitted successfully	P

4	Check test drive availability 	Test Drive Booking	Test drive slots available for selected car	Test drive slots available for selected car	P
5	Admin login with valid credentials 	User Authentication	Admin successfully logged in	Admin successfully logged in	P
6	Admin login with invalid credentials 	User Authentication	Error message displayed: "Invalid username or password"	Error message displayed: "Invalid username or password"	F
7	User login in with an already existing email id. 	User Authentication	Error message displayed: “E-mail already exists”	Error message displayed: “E-mail already exists”	F
8	User login with insufficient digits for mobile number. 	User Authentication	Error message displayed: “Mobile number contains 10 digits”	Error message displayed: “Mobile number contains 10 digits”	F

7.2 Result Analysis

The augmented reality-based car showroom project revolutionizes the car buying experience by seamlessly integrating advanced technology with practical functionality. Through the immersive power of augmented reality, users can visualize cars in their real-world environment at the touch of a button, enhancing engagement and providing a more accurate representation of their potential purchases. With user and admin login systems ensuring security and personalized experiences, users can explore inventory, access financial assistance options, and schedule test drives with ease, while administrators efficiently manage backend operations. The integration of ecommerce capabilities facilitates seamless transactions, enabling users to browse, compare, and purchase vehicles directly from the app, while test drive booking functionality adds convenience and assurance. This comprehensive approach sets new standards for automotive retail, delivering a transformative, transparent, and user-centric platform that redefines the way cars are bought and sold.

Moreover, the augmented reality-based car showroom project transcends traditional limitations of physical showrooms by offering an unparalleled level of convenience and accessibility. With the ability to explore an extensive inventory of vehicles from the comfort of their own homes, users are no longer constrained by geographical barriers or limited showroom hours. This accessibility extends to a diverse range of users, including those with mobility limitations or busy schedules, ensuring that everyone can participate in the car buying process with equal ease. By seamlessly integrating advanced technology with intuitive functionality, this innovative platform not only enhances the car buying experience but also democratizes access to information, empowering consumers to make informed decisions with confidence. As a result, the augmented reality-based car showroom project represents a significant milestone in automotive retail, marking the dawn of a new era characterized by innovation, inclusivity, and unparalleled convenience.

Figure 7.1 Shows the image that depicts a website showcasing cars for sale. A search bar allows you to find specific car models, while categories organize vehicles by body type. You can easily schedule a test drive and explore financing options. Contact information is readily available, ensuring a smooth car-buying experience.

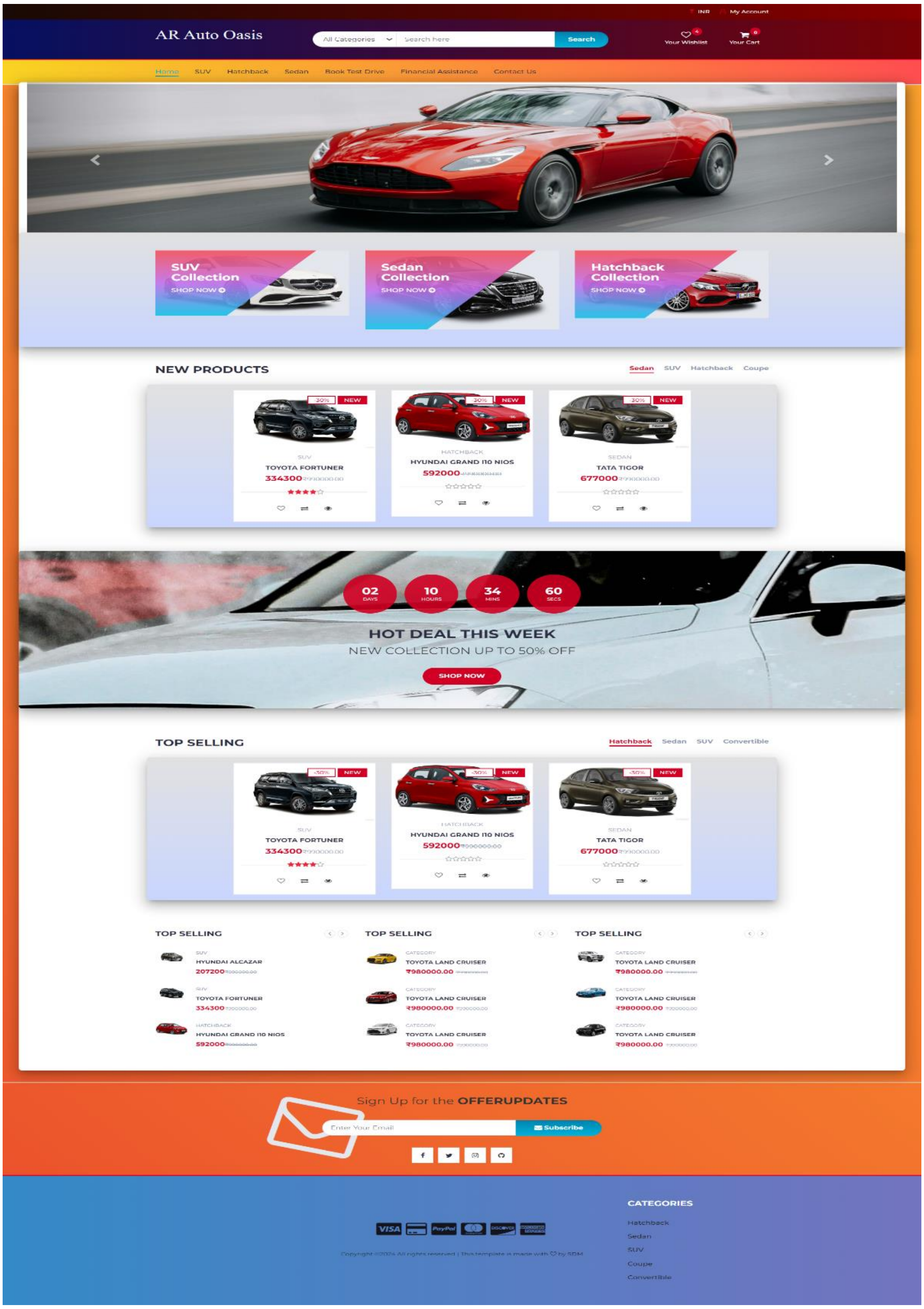


Figure 7.1: Home Page

Figure 7.2 Shows the SUV category page. This figure displays an SUV category page from website. The focus is on showcasing available SUVs to users interested in this vehicle type.

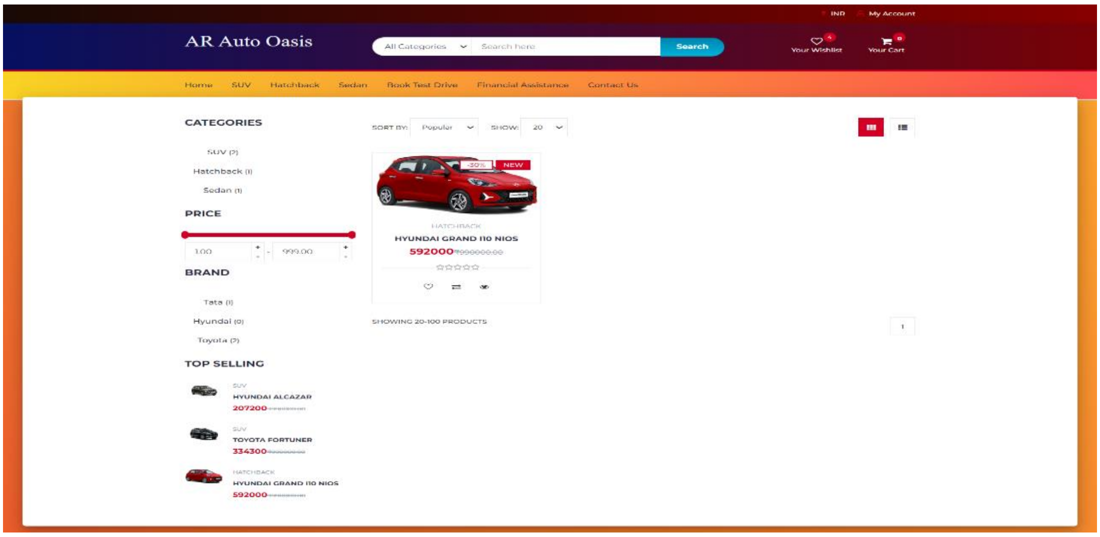


Figure 7.2: SUV category page

Figure 7.3 Shows the hatchback category page from website. The webpage aims to facilitate browsing and selection of hatchback cars for potential customers.

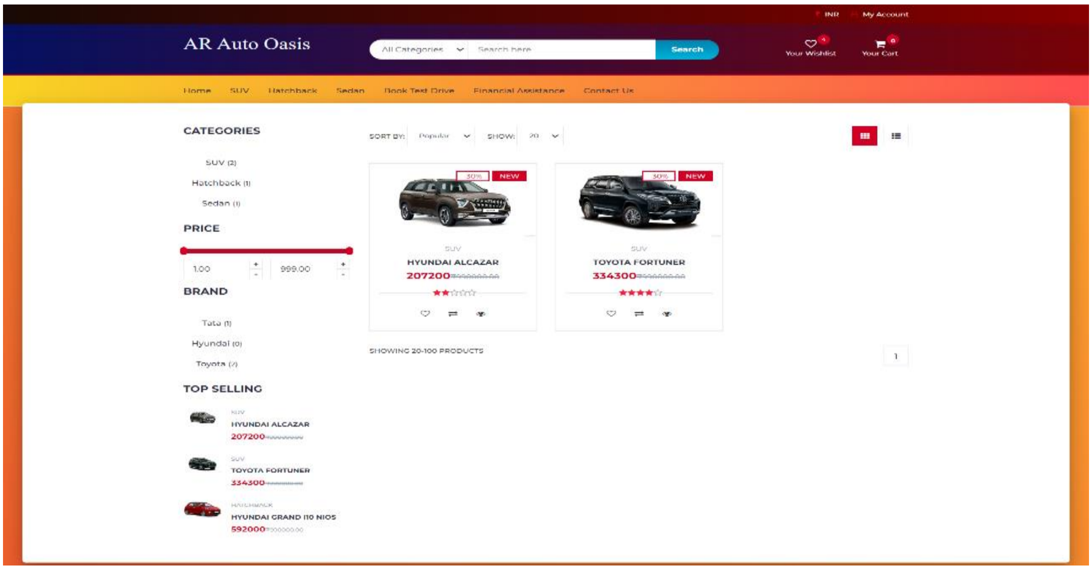


Figure 7.3: Hatchback category page

Figure 7.4 Shows the sedan category page from website. The webpage aims to showcase various sedans available for purchase.

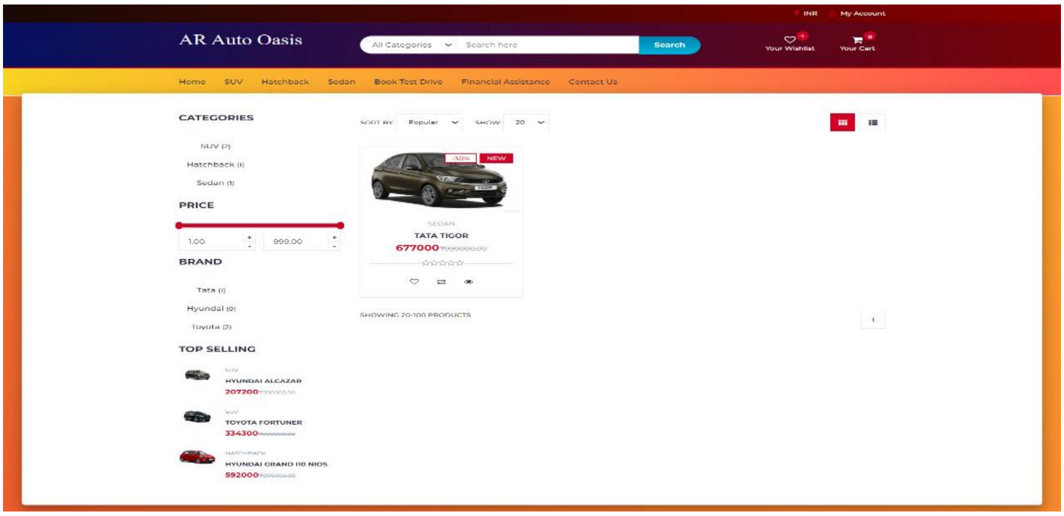


Figure 7.4: Sedan category page

Figure 7.5 Showcases an option to book a test drive that AR Oasis homepage offers a "Book Test Drive" form, suggesting a service to preview e-bookings.

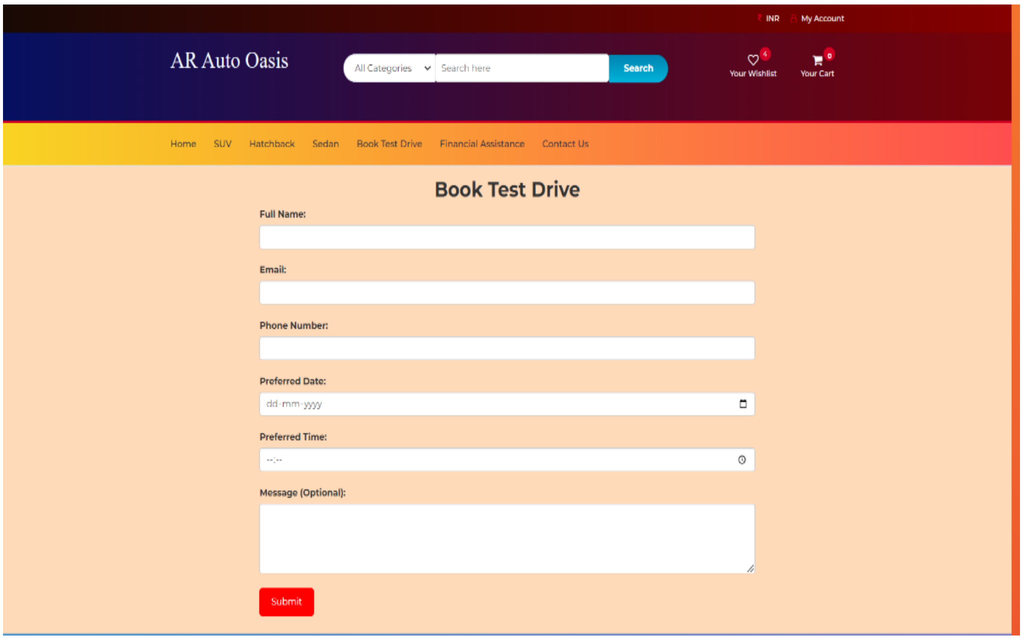


Figure 7.5: Test Drive Booking

Figure 7.6 shows car financing Assistance page where the financing form lets you to submit details like name, contact info, desired car price, and down payment to potentially secure loan assistance.

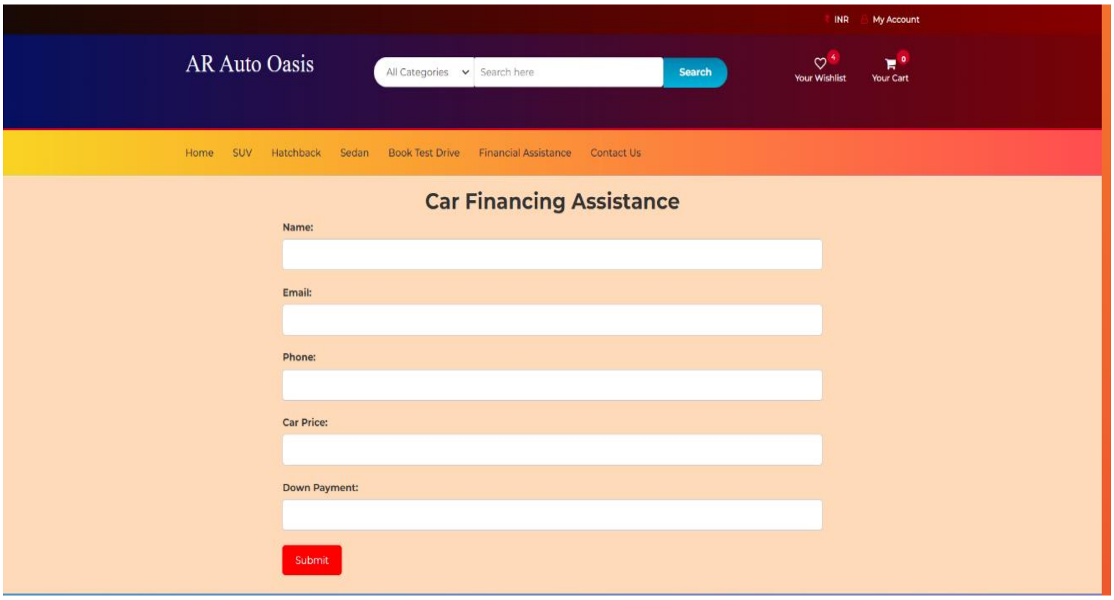


Figure 7.6: Financial Assistant

Figure 7.7 shows the Contact page. The webpage aims to provide various methods for visitors to get in touch with the website owners. A clear heading Contact Us directly communicates the page's purpose.

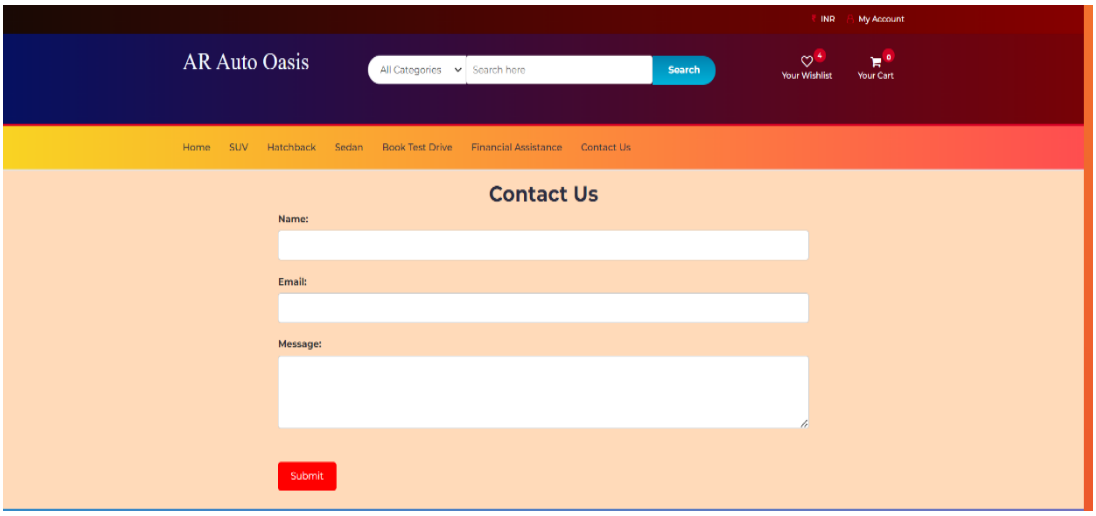


Figure 7.7: Contact Us Page

Figure 7.8 Shows notification page where subtle notification bar is present at the very top, potentially showcasing a latest released car. Users can view the latest added cars by clicking on show button.

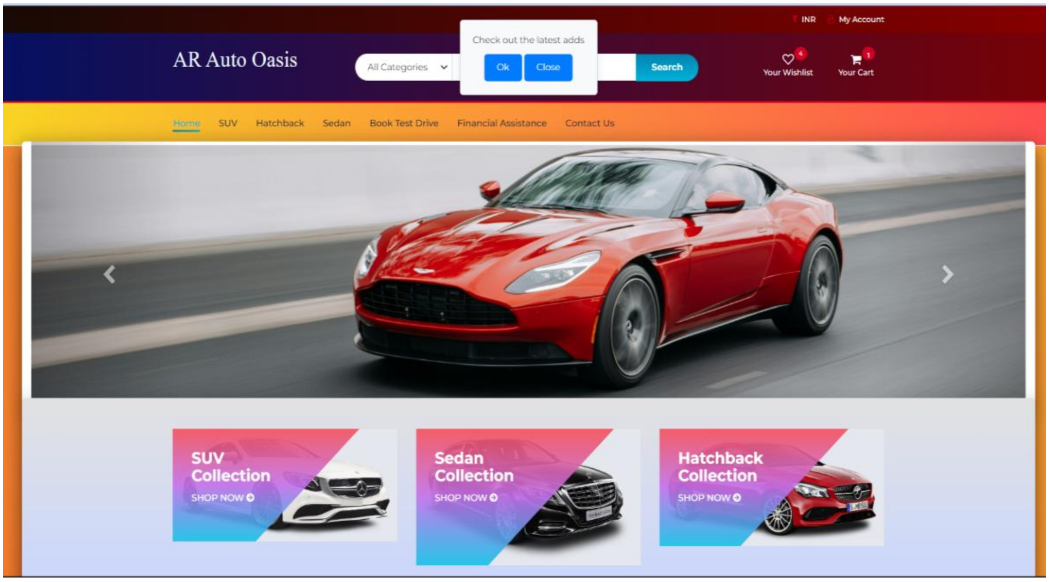


Figure 7.8: Notification about newly added cars

Figure 7.9 Shows the notification page1 on clicking the "latest cars" notification it leads to the page with detailed information about latest release. Users can view the cars efficiently by scrolling through the page.

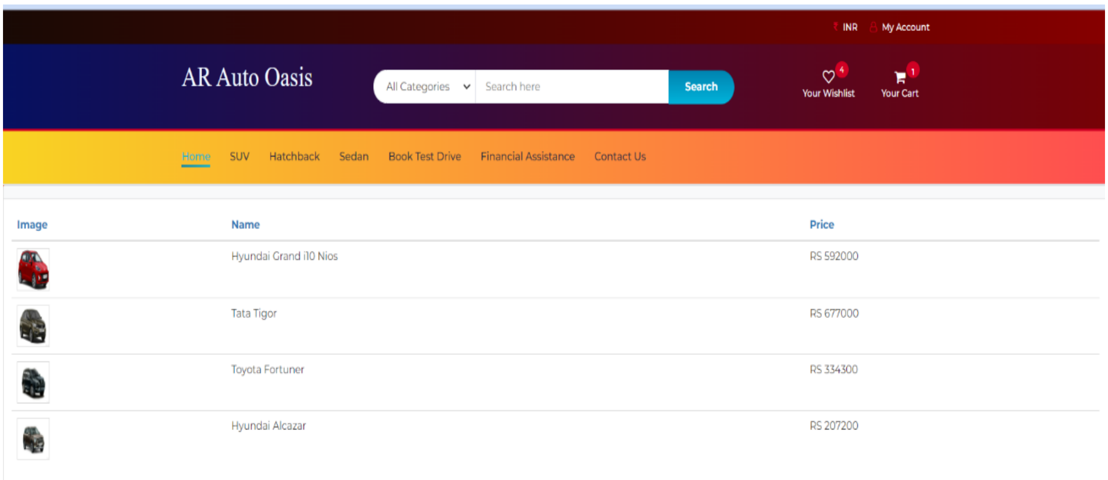


Figure 7.9: List of newly added cars

The Figure 7.10 Shows the registration page. This page requests user information such as name, email, mobile, address for registration purpose.

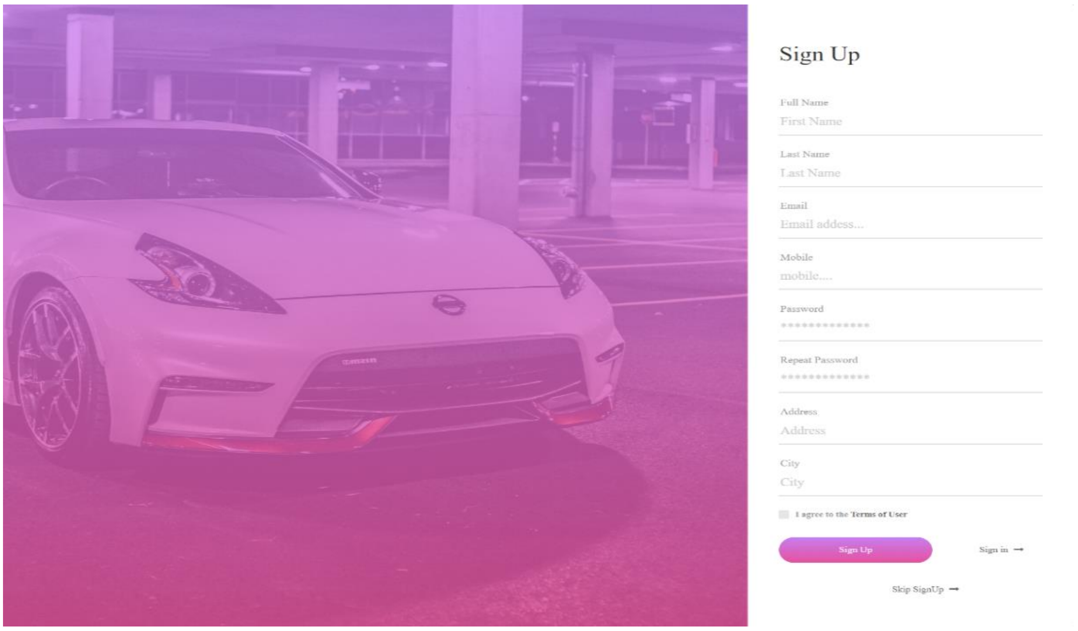


Figure 7.10: Sign Up Page

The Figure 7.11 shows login page. It typically features two sections: authentication fields, where users enter a username/email and password, and action buttons, including "Sign in" to verify credentials.

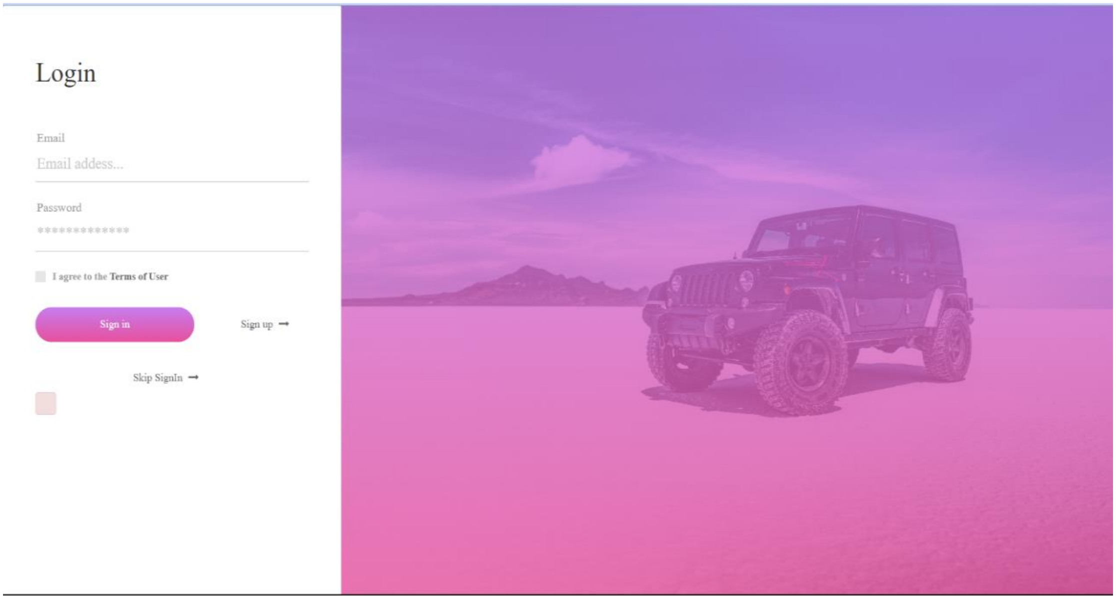


Figure 7.11: Login Page

The Figure 7.12 Shows add to cart page. It serves as a confirmation step before checkout. Key product information is typically presented, including a clear image of the chosen item, its name and price. The quantity of the desired item can likely be adjusted using "+" and "-" buttons.

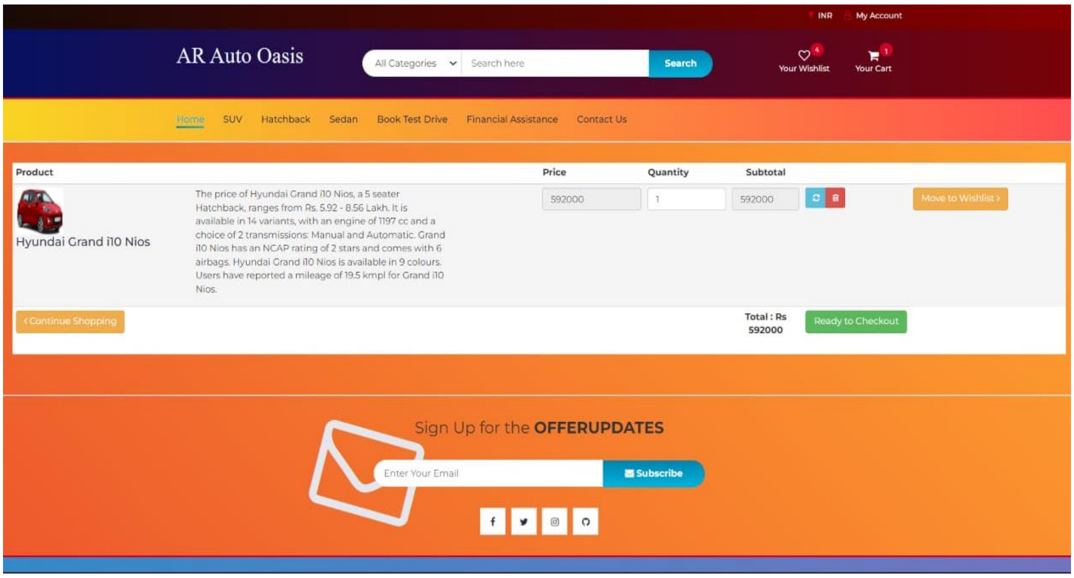


Figure 7.12: Add to cart page

The Figure 7.13 Shows the payment page it is likely a part of the process for purchasing a desired car. The page aims to collect secure payment information from the customer.

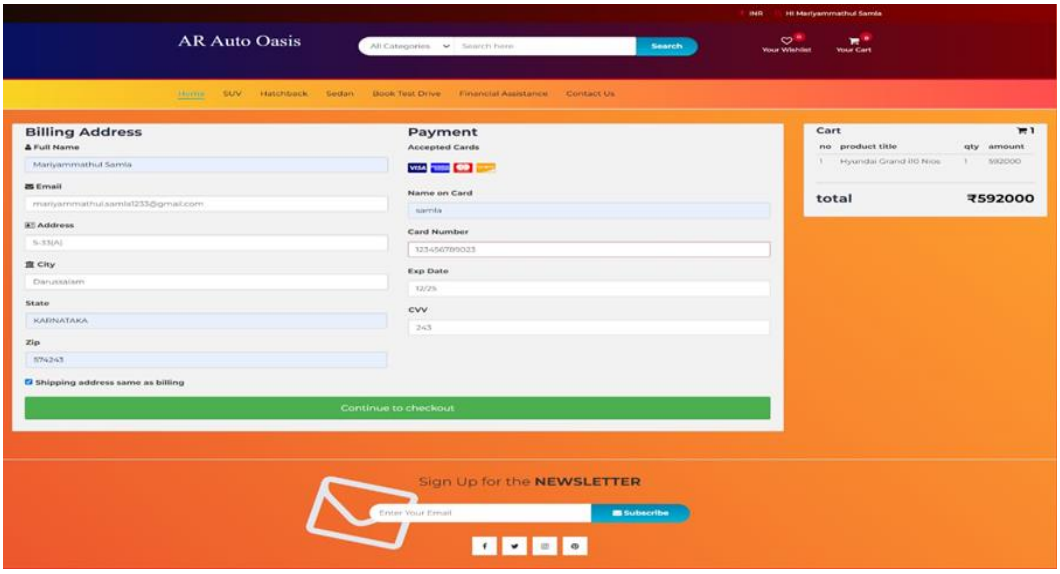


Figure 7.13: Payment Page

The Figure 7.14 Shows order success page. This webpage serves as a confirmation and informational resource after a customer successfully places an order.

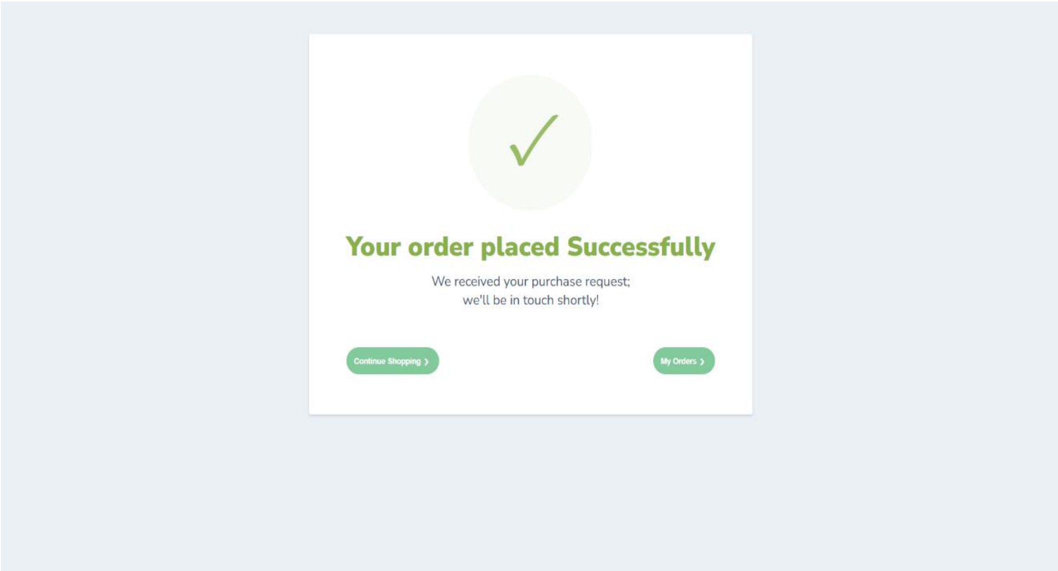


Figure 7.14: Confirmation Page

The Figure 7.15 Shows O0der list page. It provides a central location for users to track their orders. The table format showcases a list of past or current orders, potentially including details like order number, date, items ordered, total price, and order status.

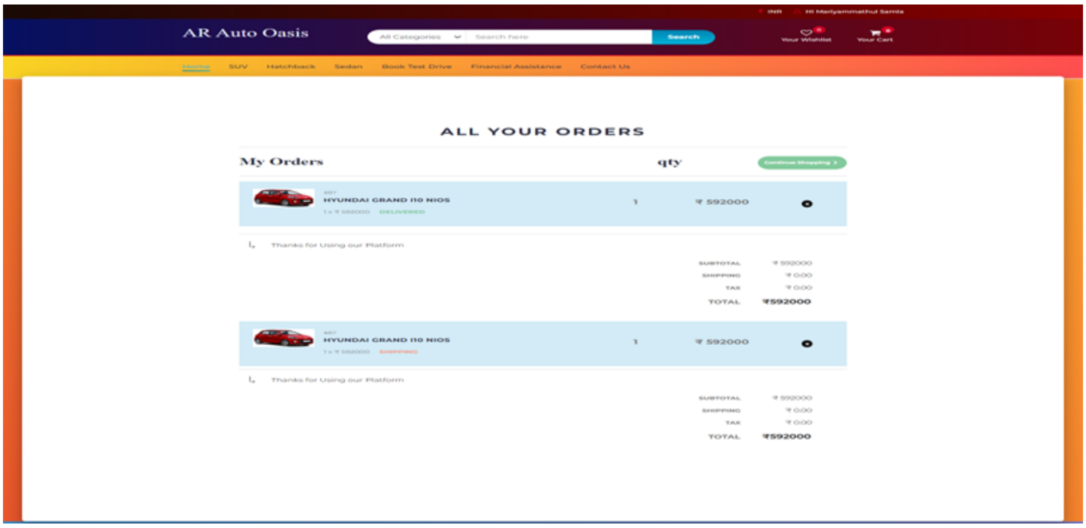


Figure 7.15: My Orders Page

Figure 7.16 depicts a formal admin login page. Emphasizing clarity and security, it follows common design patterns, designated input fields and clear action buttons to verify credentials and "Back to Home" for users who might have accessed the login page unintentionally.

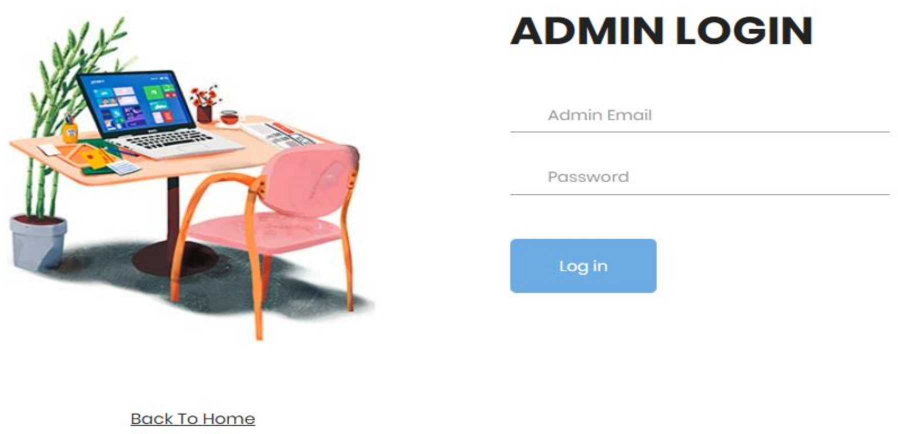


Figure 7.16: Admin Page

Figure 7.17 Showcases an online shopping system's administrative dashboard. A navigation bar grants access to various backend functions. A welcome banner greets the administrator.

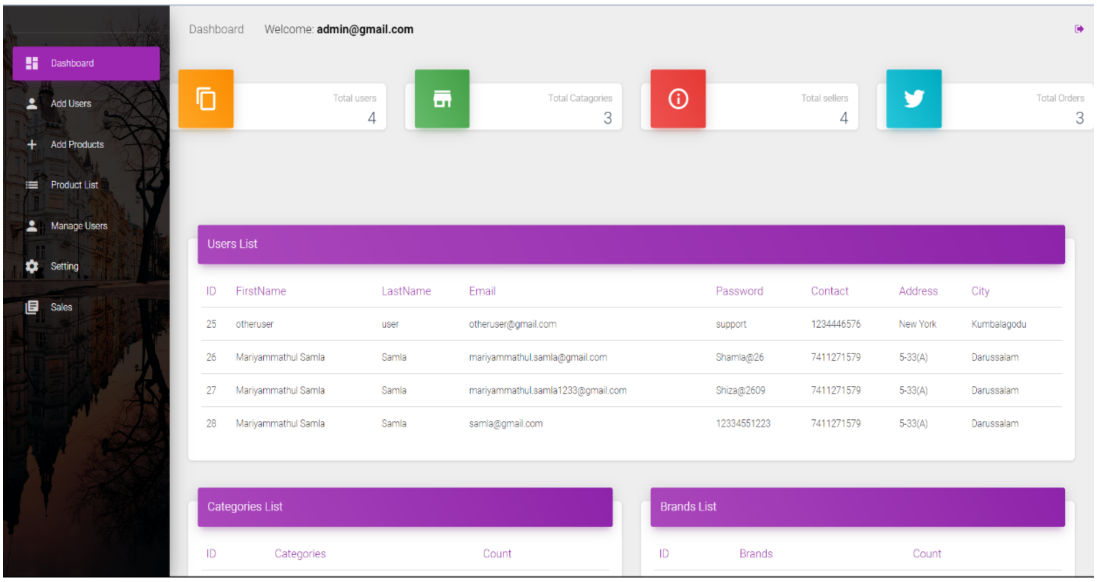


Figure 7.17: Admin Dashboard

Figure 7.18 Shows the add product page. Key product creation fields are provided for essential information, including Product title, Product description, Product category, Product image, Product brand and Product keywords.

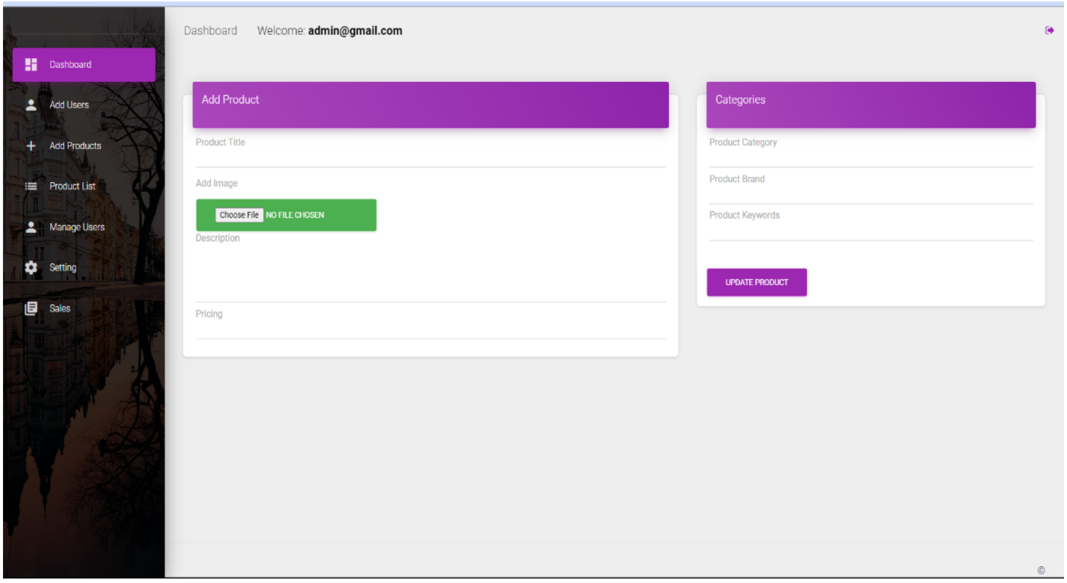


Figure 7.18: Add product page

Figure 7.19 Shows the manage user page. A table displays a list of existing users, potentially including details like username, email address, and user role. The presence of icons or buttons within the table suggests functionalities for editing or deleting user information.

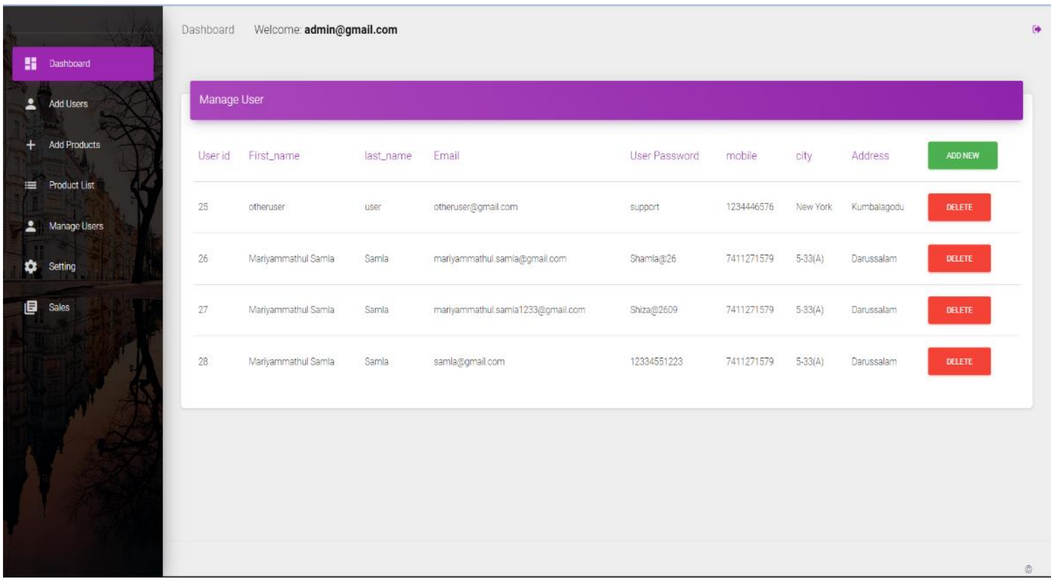


Figure 7.19: Manage User page

Figure 7.20 Shows add user page. Essential user creation functionalities are provided through designated fields, likely including Username, Email, Password and potentially role to assign user permissions.

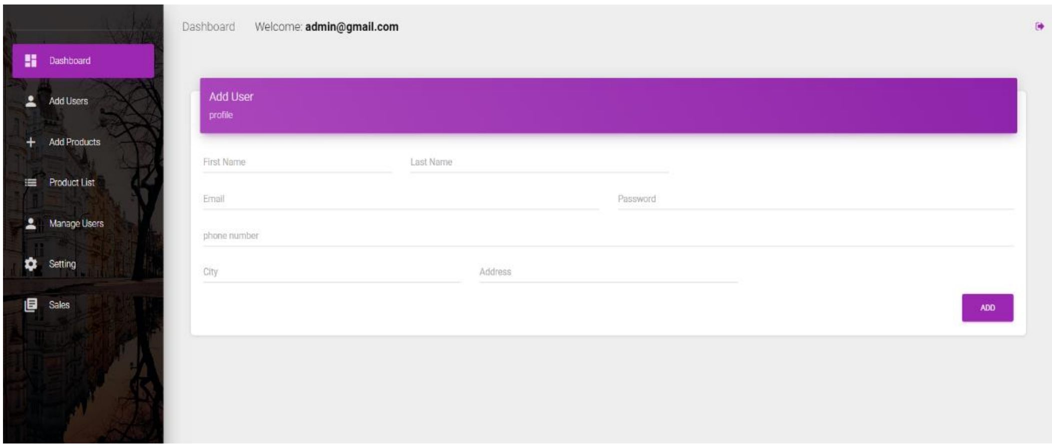


Figure 7.20: Add User page

Figure 7.21 Shows the update profile page. Key user profile sections are provided for essential information, including username, email address, current password and password confirmation fields for updating the password, all presented with clear labels.

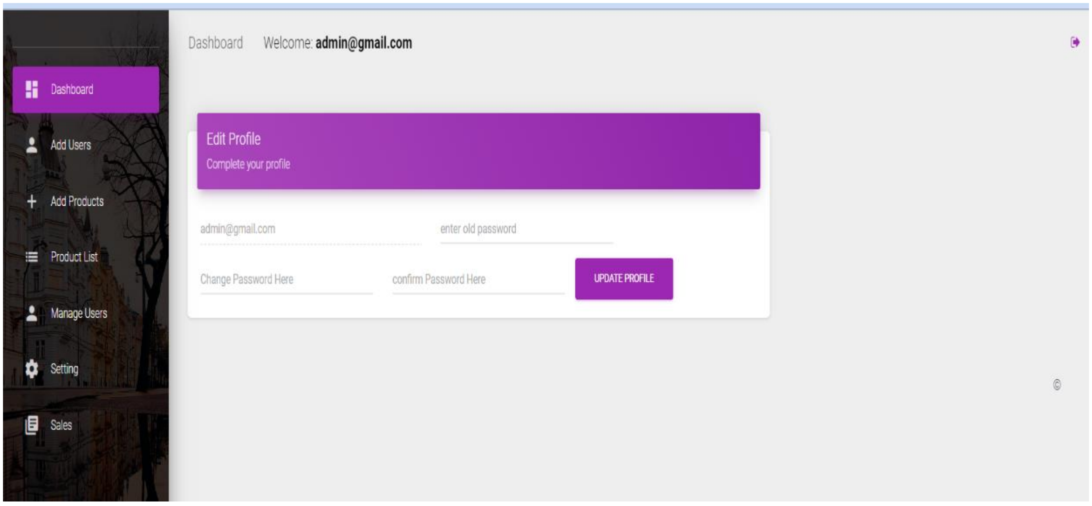


Figure 7.21: Update User page

Figure 7.22 Shows the sales page. The page aims to convince visitors to make a purchase. A prominent headline or image likely captures attention and introduces the product or service. Key benefits are likely highlighted, emphasizing how the product or service solves customer problems or fulfills their needs.

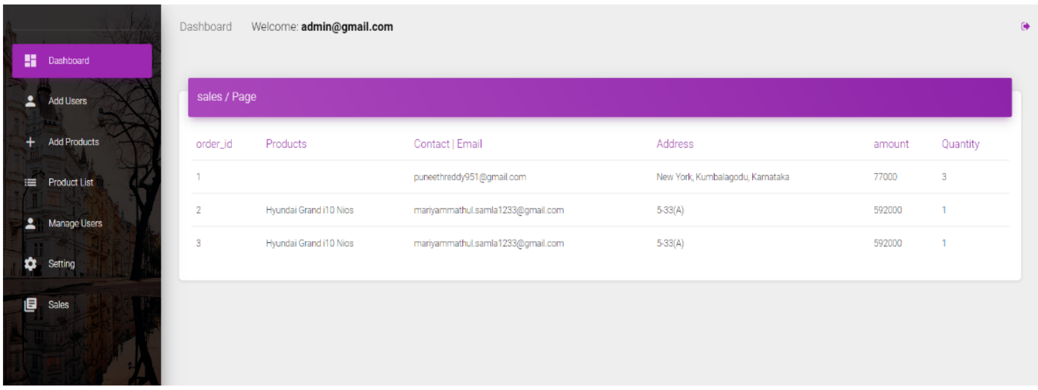


Figure 7.22: Sales page

Figure 7.23 Shows the image of product list page. A prominent heading likely indicates the product category. Each product listing showcases essential details like a product image, name and potentially price.

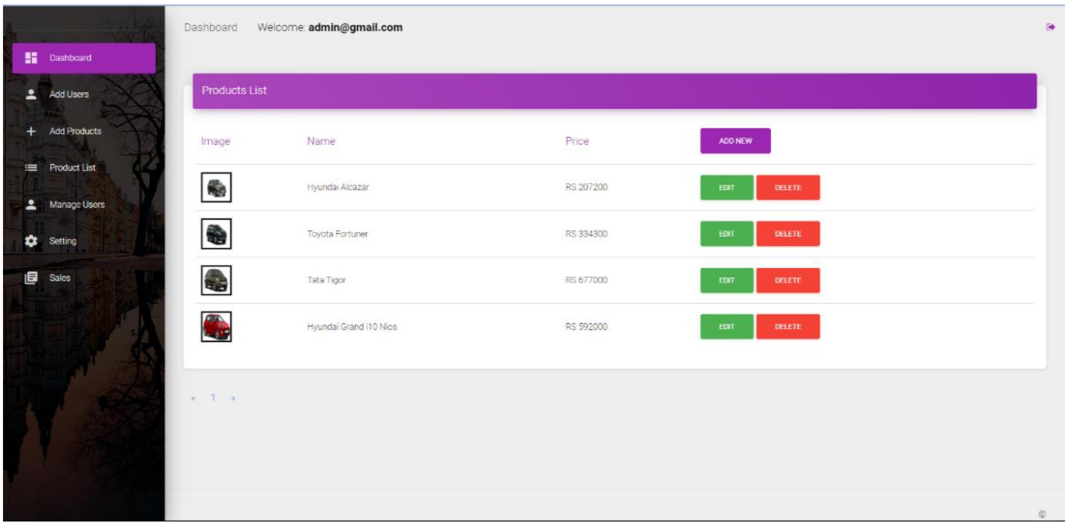


Figure 7.23: Product list page

Figure 7.24 Shows the steps to be undertaken on clicking view in space option for AR projection of the desired car. As the initial step a prompt appears asking to select the account.

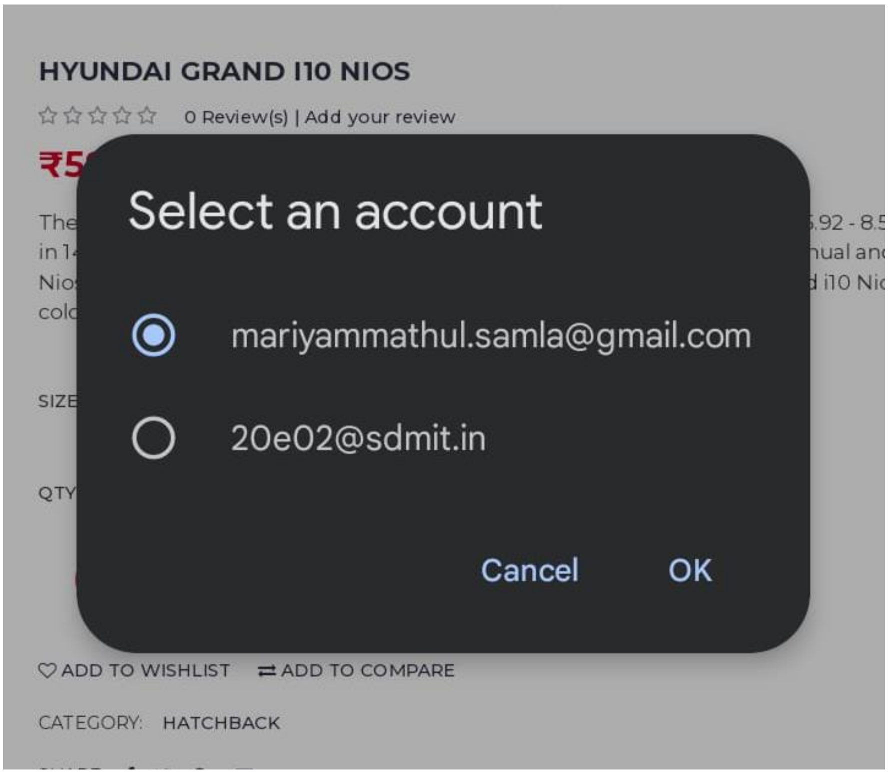


Figure 7.24: Account selection

Figure 7.25 Shows the page that asks to click on package installer for installing the AR app in the mobile.

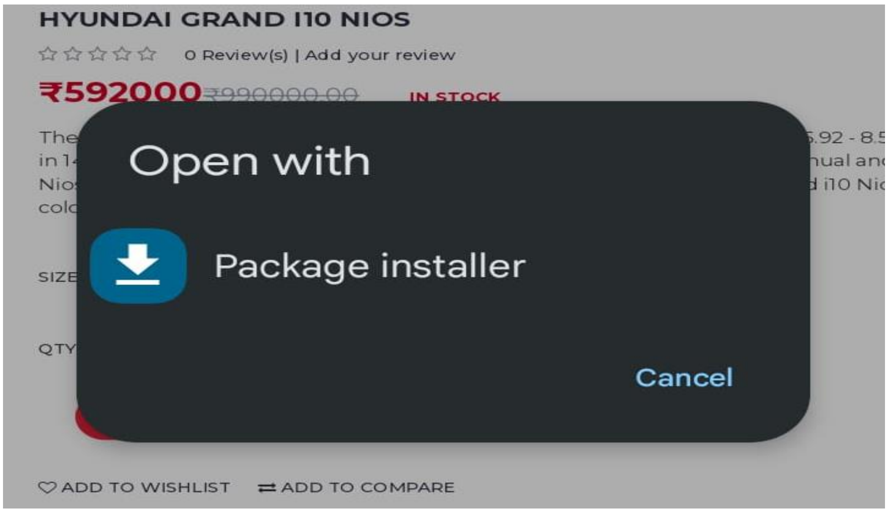


Figure 7.25: Package Installer

Figure 7.26 Shows the next step once after the package installer is clicked. The app starts to load and staging of the app starts.

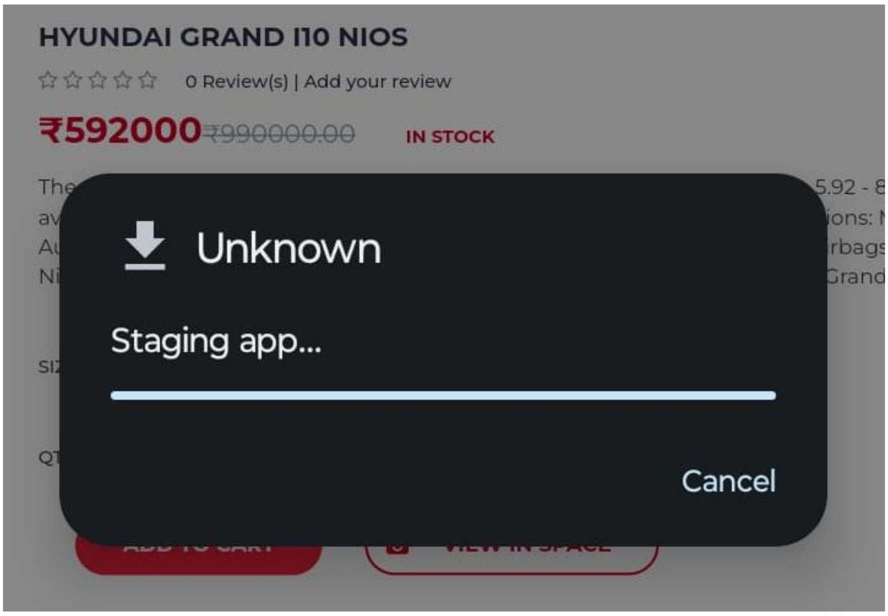


Figure 7.26: Staging of the app

Figure 7.27 Shows the prompt that asks to install the AR app. The app gets installed in the mobile so that user can refer to it at later time also.

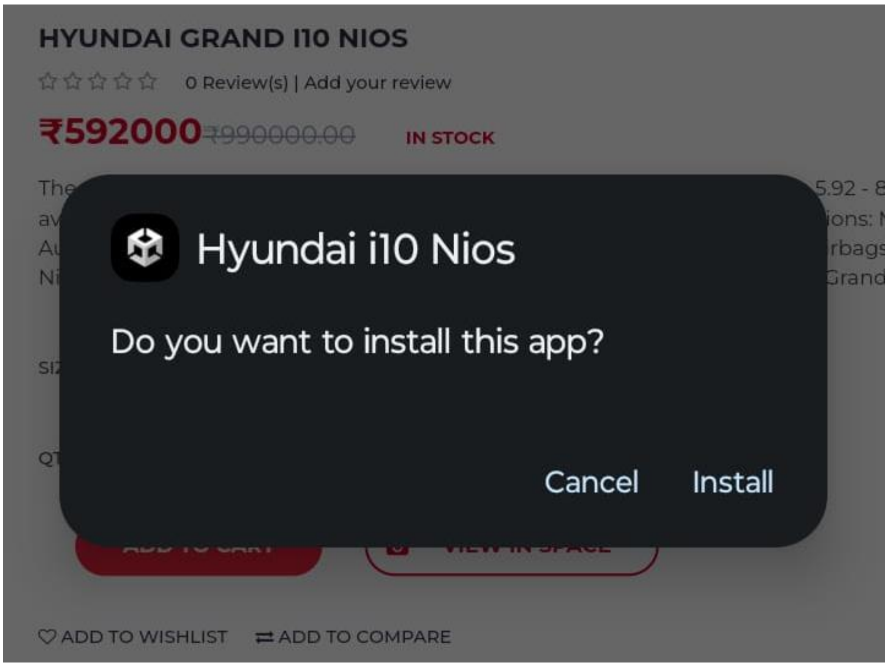


Figure 7.27: Prompt to install app

Figure 7.28 shows the user that once the install app is clicked the app is installed and user is notified with the message.

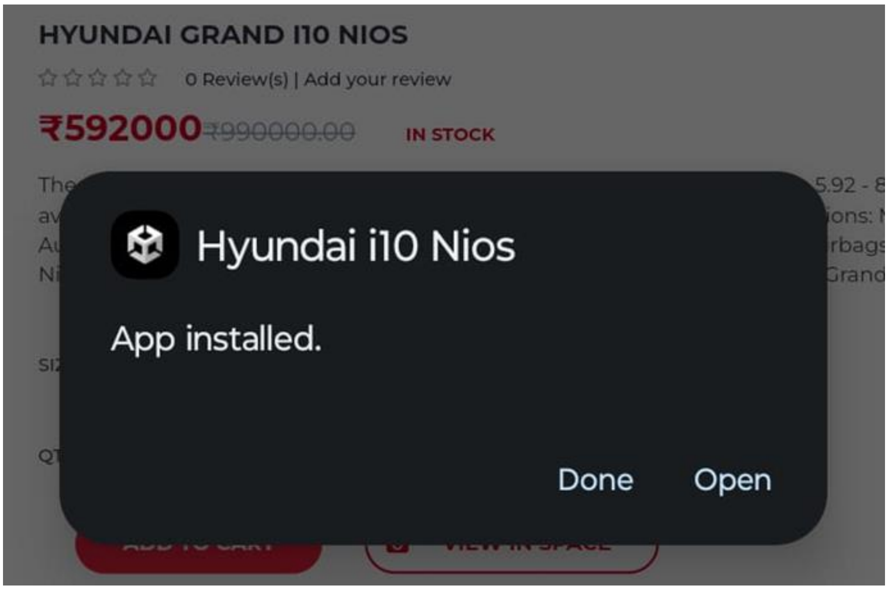


Figure 7.28: Successful installation of the app.

Figure 7.29 Shows the opening of the app once installed. As the Unity3D platform is used to create the AR projection so the app opens up with Unity interface.

Figure 7.29: Opening of the app.

Figure 7.30 Shows the page that asks to select the camera options to render the augmented projection of the car.

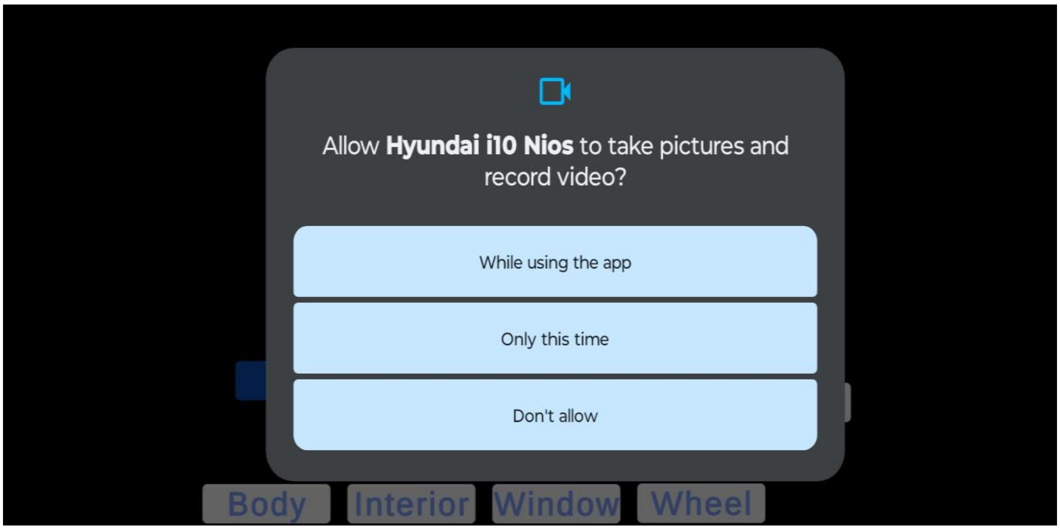


Figure 7.30: Opting the camera options

Figure 7.31 Shows the augmented projection of the car in the real world where different options are provided like 360-degree view, the colors available in the specified model and other viewing options for customization.

Figure 7.31: Augmented projection of the car

Figure 7.32 Shows the blue color selected by the user to look into the available colors and its real time view.

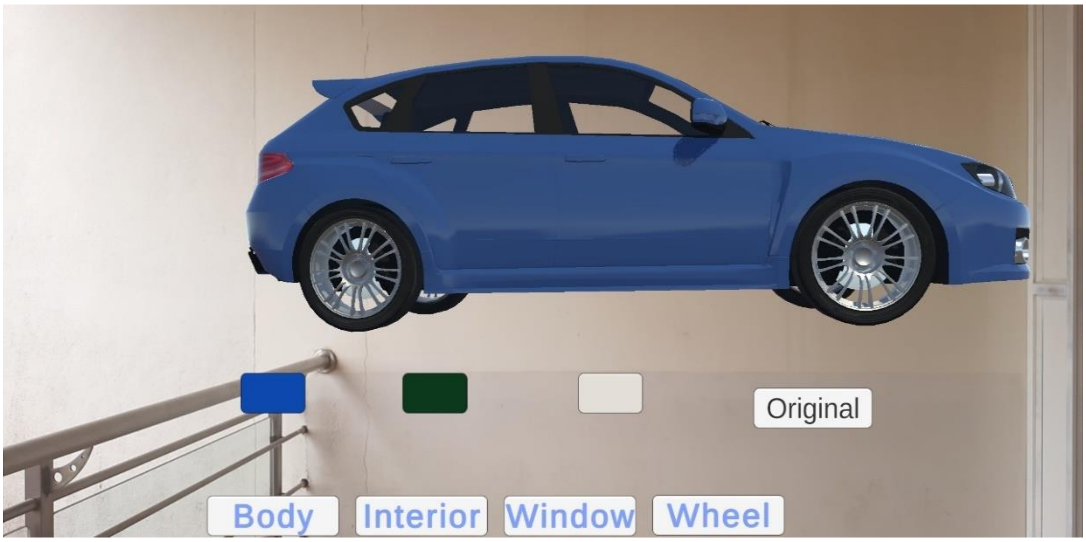


Figure 7.32: Augmented projection of the car with blue color

Figure 7.33 Shows the spark green color selected by the user to look into the available colors and its real time view.

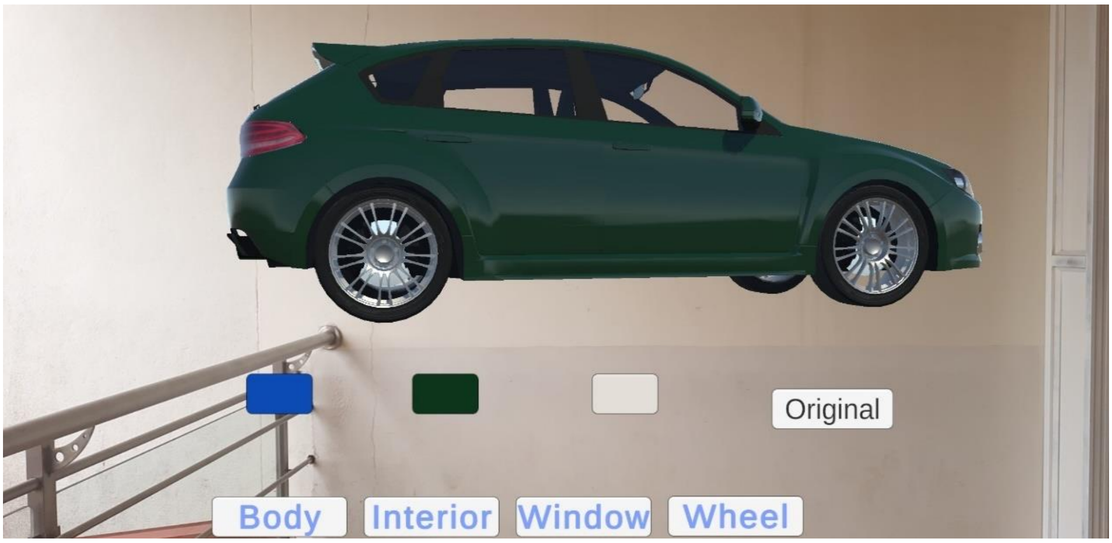


Figure 7.33: Augmented projection of the car with spark green color

Figure 7.34 Shows the white color selected by the user to look into the available colors and its real time view.

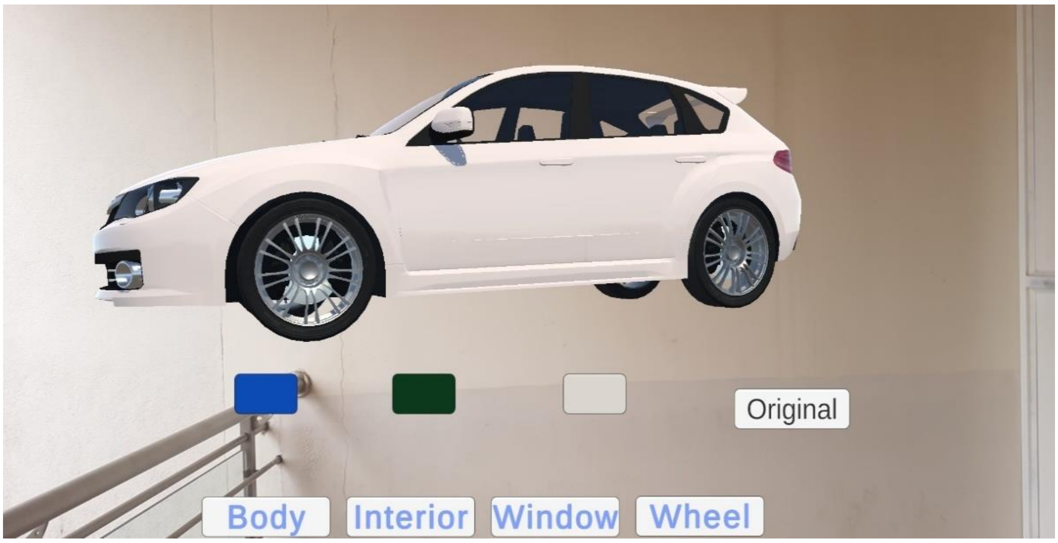


Figure 7.34: Augmented projection of the car with white color

Figure 7.35 shows the option to view the car by toggling or removing the body to look into the inner aspects of the car.

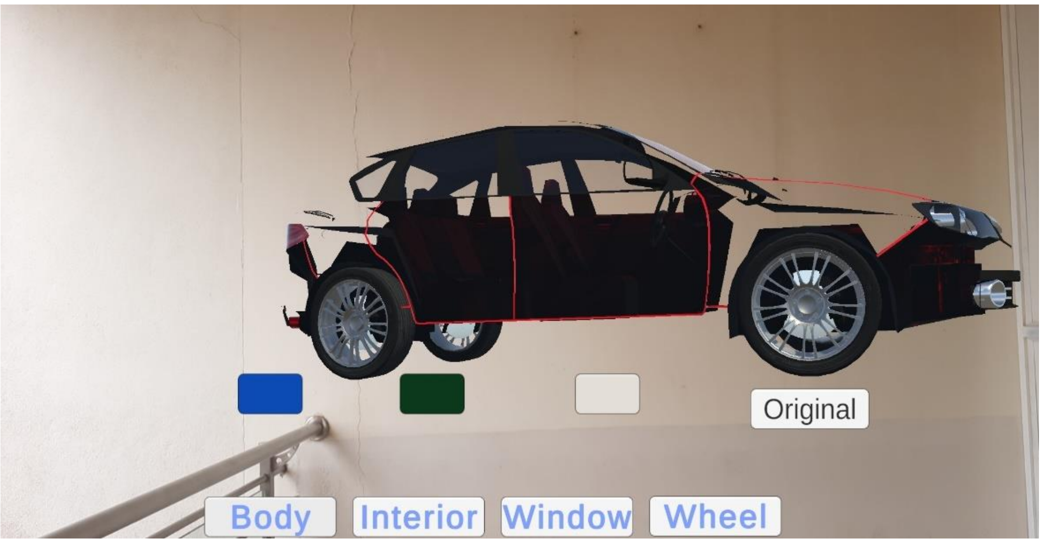


Figure 7.35: Augmented projection of the car with toggling of the body.

Figure 7.36 shows the option to view the car by toggling or removing the interior to look into the inner aspects of the car.

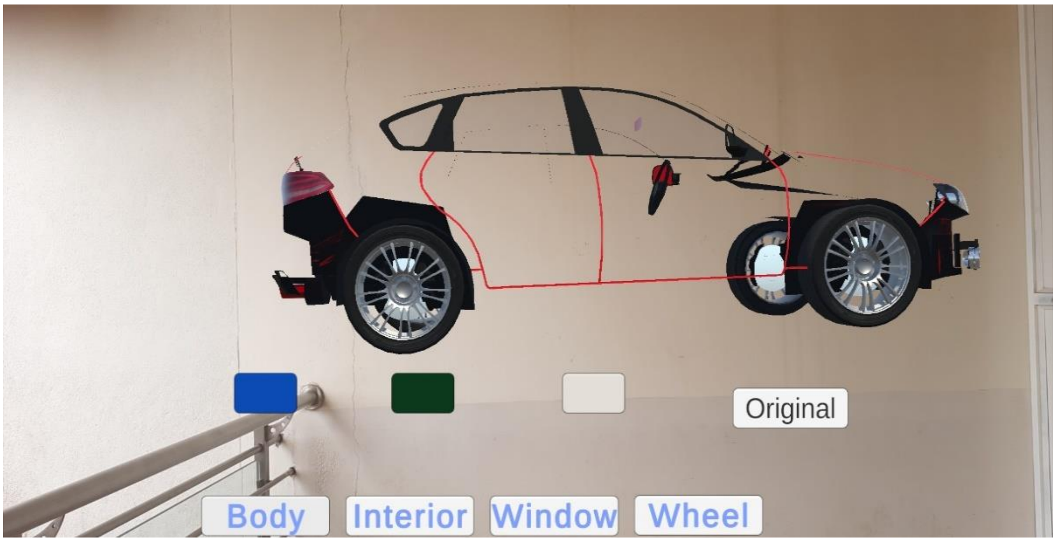


Figure 7.36: Augmented projection of the car with toggling of the interior

Figure 7.37 shows the option to view the car by toggling or removing the window to look into the inner aspects of the car.

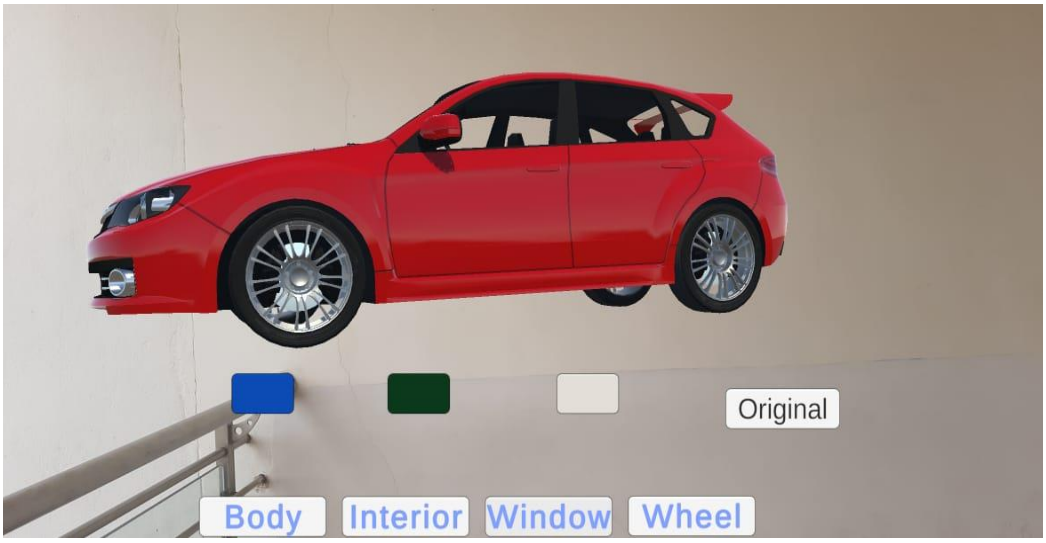


Figure 7.37: Augmented projection of the car with toggling of the window.

Figure 7.38 shows the option to view the car by toggling or removing the wheel to look into the inner aspects of the car.

Figure 7.38: Augmented projection of the car with toggling of the wheel

Figure 7.39 shows the returning of the car's color to its original color on clicking the button named original.

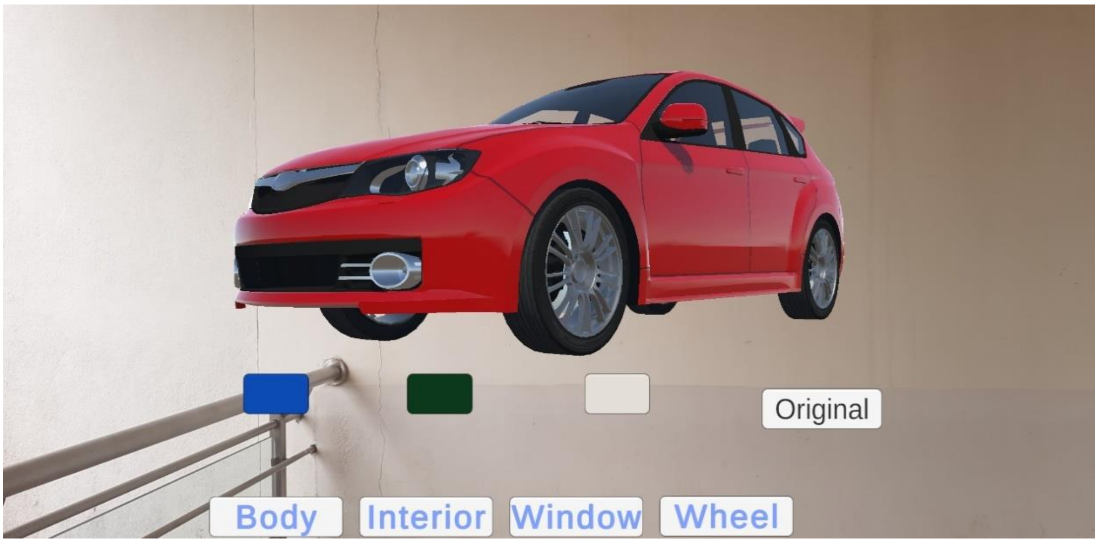


Figure 7.39: Returning of the red color of the car on clicking button named original.

7.3 Summary

The results indicate a successful validation of each tested component. Users were able to seamlessly authenticate themselves, either with valid credentials leading to successful login or with invalid credentials prompting the expected error message. The ecommerce store functioned efficiently, allowing users to add and remove cars from their cart without any issues. Additionally, the financial assistance feature facilitated the smooth submission of applications. The AR car visualization feature performed exceptionally well, accurately displaying virtual car models in the real-world environment as intended. Test drive booking and inventory management functionalities were also successfully validated. Administrators could easily access the system, both with valid and invalid credentials, and efficiently manage inventory. Overall, the system testing phase confirmed the robustness and effectiveness of the augmented reality-based car showroom, ensuring a seamless and satisfactory user experience.

Chapter 8

Conclusion and Scope for Future Work

8.1 Conclusion

The project proposes an efficient method for improvising the user experience by rendering augmented reality using Unity3D. The implementation of augmented reality (AR) in the car showcase not only enhances the traditional automotive retail experience but also revolutionizes it by providing an immersive and interactive platform for potential buyers. Through the utilization of AR technology, customers can visualize and customize vehicles in real-time, gaining a more profound understanding of design options and features. This not only fosters informed decision-making but also creates a memorable and engaging experience, elevating the overall perception of the brand. Additionally, the integration of AR contributes to increased customer satisfaction, as it bridges the gap between online research and the physical showroom, offering a seamless transition in the car-buying journey. As the automotive industry continues to evolve, embracing augmented reality not only aligns with the demands of tech-savvy consumers but also sets the stage for a future where innovation and experiential marketing converge to redefine the dynamics of automotive retail.

8.2 Scope for Future Work

The future of augmented reality in car showcases promises a paradigm shift in the automotive industry, with boundless opportunities awaiting exploration. Through AR, prospective buyers can virtually explore car models in rich detail, customize their vehicles, and make informed decisions from the comfort of their homes. Moreover, AR holds the potential to revolutionize product education and training, empowering both customers and dealership staff with interactive tutorials and simulations. Remote assistance and support are also poised for transformation, as AR applications enable technicians to diagnose issues remotely and guide customers through troubleshooting procedures in real-time. Integration with smart devices and the IoT ecosystem opens doors to seamless connectivity and personalized experiences, while collaborative design and prototyping tools streamline development processes. In essence, the future of AR in car showcases is a compelling narrative of innovation, where technology converges with human-centric design to elevate the automotive experience to new heights.

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