AUGMENTED REALITY TRAVEL APPLICATION

A

Report submitted in partial fulfilment of the requirement

for the

degree of

BACHELOR OF TECHNOLOGY

In

Computer Science & Engineering

By

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Under the Supervision of

Dr. Ravi Sharma, Assistant Professor

Pranveer Singh Institute of Technology, Kanpur

Dr A.P.J. Abdul Kalam Technical University

Lucknow

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Certificate

This is to certify that the Project Report entitled "**An Augmented Reality Travel Application**" which is submitted by **Shubham Rastogi** and **Tarun Singh** in partial fulfillment of the requirement for the award of degree B. Tech. in the Department of **Computer Science and Engineering** of **Pranveer Singh Institute of Technology,** affiliated to **Dr. A.P.J. Abdul Kalam Technical University**, Lucknow is a record of the candidates own work carried out by them under my/our supervision. The project embodies the result of original work and studies carried out by the students themselves and the contents of the project do not form the basis for the award of any other degree to the candidate or to anybody else.

Signature:

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Department of Computer Science and Engineering
PSIT, Kanpur

Date:

DECLARATION

We hereby declare that this submission is our own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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ABSTRACT

This report provides an analysis of the Augmented Reality (AR) Travel Application, a groundbreaking platform integrating augmented reality, geolocation services, and comprehensive booking functionalities. The report discusses the development process, key features, testing analysis, and user feedback. The application offers an immersive travel experience by overlaying virtual information on real-world destinations. Geolocation services enable accurate navigation, while the integrated booking system simplifies travel arrangements. Testing and user feedback reveal high user satisfaction and engagement. The report identifies areas for improvement, such as device compatibility and content expansion. The findings highlight the application's impact on the travel industry and emphasize the importance of user feedback for ongoing enhancements. Overall, the Augmented Reality Travel Application transforms travel exploration, combining technology and convenience to redefine user experiences.

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CHAPTER 1
INTRODUCTION

1.1 Motivation

The human desire to explore new places and experience new things has been a fundamental driving force throughout history. In the past, this desire was satisfied through expeditions to far-off lands or leisurely travels. However, with the advancement of technology and research, modern society has been able to travel to every corner of the world with ease, be it by plane, ship, or train. In addition to this, the field of computer technology has grown by leaps and bounds in recent decades, leading to the creation of powerful devices that fit in the palm of your hand - smartphones. These devices act as miniature "supercomputers" that provide access to the internet, GPS, accelerometers, and other useful features. With the help of these smartphones and the thousands of applications available on the two main operating systems, people can find information and entertainment from anywhere in the world.

Tourism experiences can be classified into a hierarchy (Figure 1.1), with each level offering a different degree of involvement and engagement. The first level is the basic or functional experience, which involves meeting basic needs such as food, shelter, and transportation. The next level is the emotional experience, which involves connecting with the place or activity emotionally. The third level is the intellectual experience, which involves learning about the history, culture, and traditions of the destination. The fourth and highest level is the transformational experience, which involves a profound change in the tourist's perspective or way of life. This hierarchy of experiences helps tourists to choose the type of experience they desire and helps tourism operators to design and market their products accordingly.

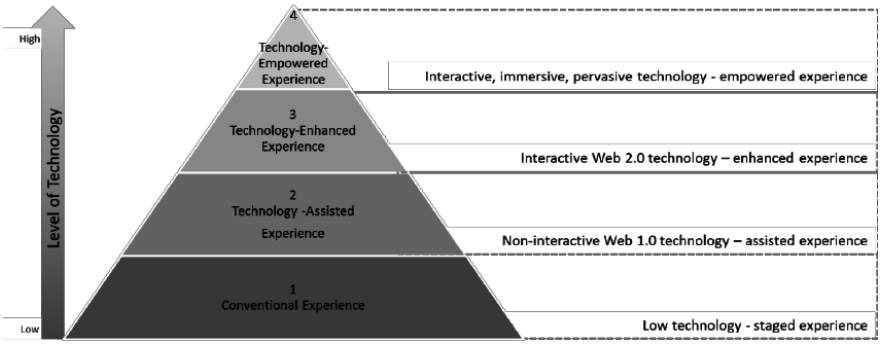

Figure 1.1 Hierarchy of experiences in tourism

The concept of Augmented Reality has existed since the 1960s, and technological advancement today has made this concept successfully employed and become more mainstream over the world. AR is a feature that enhances real-world visualization by bringing virtual to the real-world environment which is the opposite of Virtual Reality. Smartphones with built-in cameras, and integrated GPS have further driven the formulation of AR which increases the accessibility of this feature to everyone. Consumers can interact with their surroundings using the smartphone camera through AR features.

1.2. Background of Problem

The tourism industry has witnessed significant growth in recent years with the emergence of technology-driven travel experiences. Augmented reality (AR) has become an increasingly popular technology in various fields, including tourism. However, there needs to be more comprehensive research on the use of AR in travel applications. In the tourism industry, AR has been used to enhance the travel experience of visitors by providing them with real-time information and visualizations of their surroundings. For example, AR can offer visitors an interactive tour of historical sites, providing them with information on the site's history and architecture while visualizing the site as it may have appeared in the past. AR can also provide travelers with real-time information on nearby attractions, restaurants, and events. The use of AR in the tourism industry is still in its early stages, but it is rapidly gaining popularity among travelers and tourism businesses. With the increasing availability

and affordability of AR technology, it will continue to grow and evolve, offering travelers even more innovative and immersive travel experiences in the future.

The tourism industry faces several challenges that can impact its growth and sustainability. Here are some of the most significant challenges faced in the tourism industry:

1. COVID-19 Pandemic: The COVID-19 pandemic has had a significant impact on the tourism industry. Travel restrictions, lockdowns, and social distancing measures have led to a significant decline in tourism worldwide.

2. Climate Change: Climate change has become a major concern for the tourism industry. It can result in extreme weather events, natural disasters, and loss of biodiversity, which can affect travel destinations and lead to reduced visitor numbers.

3. Overcrowding: Popular tourist destinations often face the problem of overcrowding, which can lead to environmental degradation, strain on infrastructure, and a negative impact on local communities.

4. Changing Consumer Demands: Consumer preferences and demands are constantly evolving, and the tourism industry needs to keep up with these changes. Travelers are becoming more environmentally conscious, seeking more authentic experiences, and using technology more frequently to plan and book their trips.

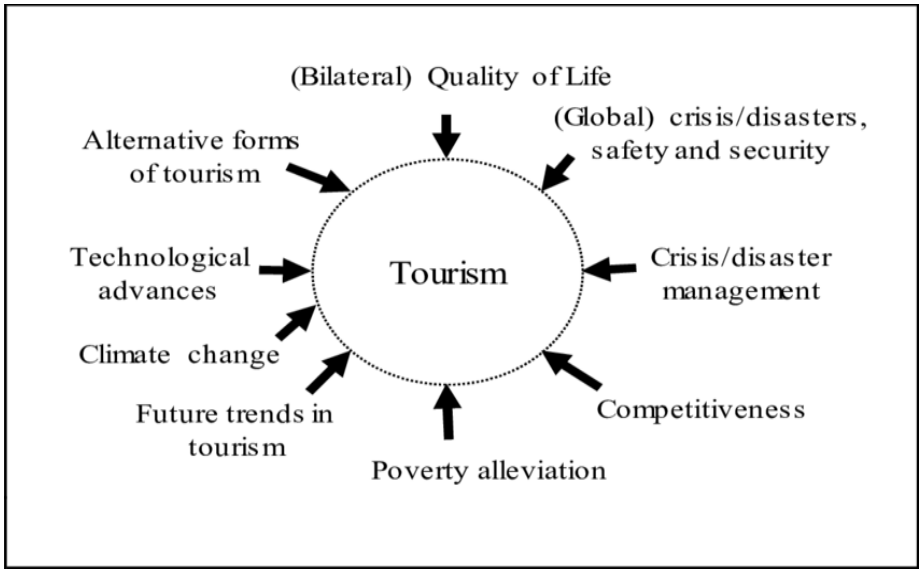

Figure 1.2 Challenges faced by tourism industry

These issues paves a way for augmented reality travel applications that offer a more immersive and interactive experience for travelers, using smartphone cameras to overlay digital information on the real-world environment. AR travel apps provide real-time information, such as historical facts, reviews, and directions, that enhance users' understanding of the destination and help them make informed decisions. These apps help users navigate unfamiliar environments more easily by displaying directions and information in an interactive way. AR travel apps provide a unique marketing opportunity for tourism operators and destinations by showcasing their attractions in an engaging way that attracts more visitors and encourages repeat visits.

1.2.1. Augmented Reality

Augmented Reality (AR) as a field can be traced back to the late 1960s and the term was first used in the early 1990s by Caudell and Mizell—former Boeing engineers seeking to display simple information (e. g., text) in 3D space to enhance manufacturing processes.

Since then, researchers have continued to improve AR hardware, algorithms, and user interfaces, with several communities showing interest in augmenting physical reality with

virtual content. AR has been applied to medicine, education, archaeology, games, remote expert guidance, industry, crisis response, and information visualization.
Since 2016, AR Head-Mounted Displays (AR-HMDs) have become much more affordable and closer to consumer markets with the release of Microsoft's HoloLens and HoloLens 2, the Meta 2, and Magic Leap One, all priced at US$ 3500 or less, and supporting Unity as an accessible SDK. Over the same period, smartphone applications (e. g., the Pokemon Go game) have increased the public's knowledge of, and interest in augmented reality.

Another way of defining Augmented Reality is in the context of other technologies. Milgram and Kishino [1994] introduced the concept of "Mixed Reality", which is the merging together of real and virtual worlds, and a Mixed Reality continuum which is a taxonomy of the various ways in which the "virtual" and "real" elements can be combined together (see Figure 1.3).

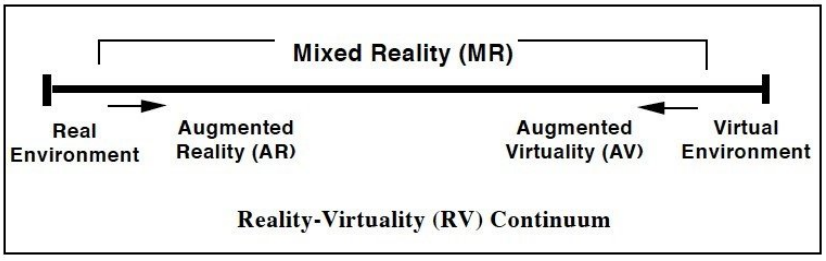

Fig. 1.3 Milgram and Kishino's reality-virtuality continuum.

On the right end is the Virtual Environment (VE), where the user's view of the world is completely replaced by computer-generated virtual content. On the opposite left end is the Real Environment (RE) where none of the user's view is replaced by virtual content. Towards the VE end is Augmented Virtuality where most of the user's view is replaced by computer graphics, but there is still a view of the real world available. Finally, Augmented Reality is closer to the RE end, where virtual cues enhance the user's view of the real world. As more or less virtual content is added to the AR scene the interface moves closer or further away from the VE or RE endpoints. The main lesson from this taxonomy is that

AR interfaces don’t exist as a discrete point between Real and Virtual experiences, but can appear anywhere along the Mixed Reality continuum.

The Metaverse roadmap categorizes the AR experience based on Neal Stephenson's concept of the Metaverse. The roadmap uses two continua to classify the spectrum of technologies and applications, ranging from augmentation to simulation, and from intimate to external. Augmentation technologies add new capabilities to existing systems, while simulation technologies model reality. Intimate technologies are focused inwardly on the individual's identity and actions, while external technologies are focused outwardly on the world. Augmented Reality, Virtual Worlds, Life Logging, and Mirror Worlds can be arranged within these continua. (see Figure 1.4)

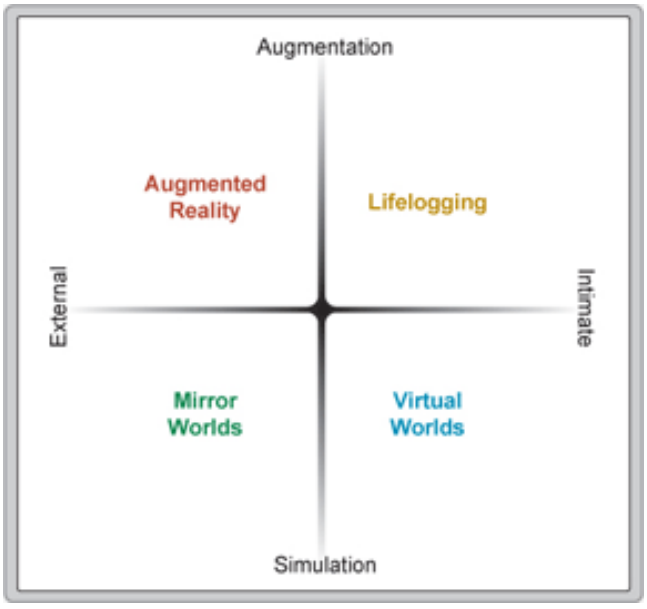

Figure 1.4 : Augmented Reality in the Metaverse taxonomy

1.2.2. Geolocation

Geolocation refers to the identification of the geographic location of a user or computing device via a variety of data collection mechanisms. Typically, most geolocation services use network routing addresses or internal GPS devices to determine this location. Geolocation is a device-specific API. This means that browsers or devices must support geolocation in order to use it through web applications.

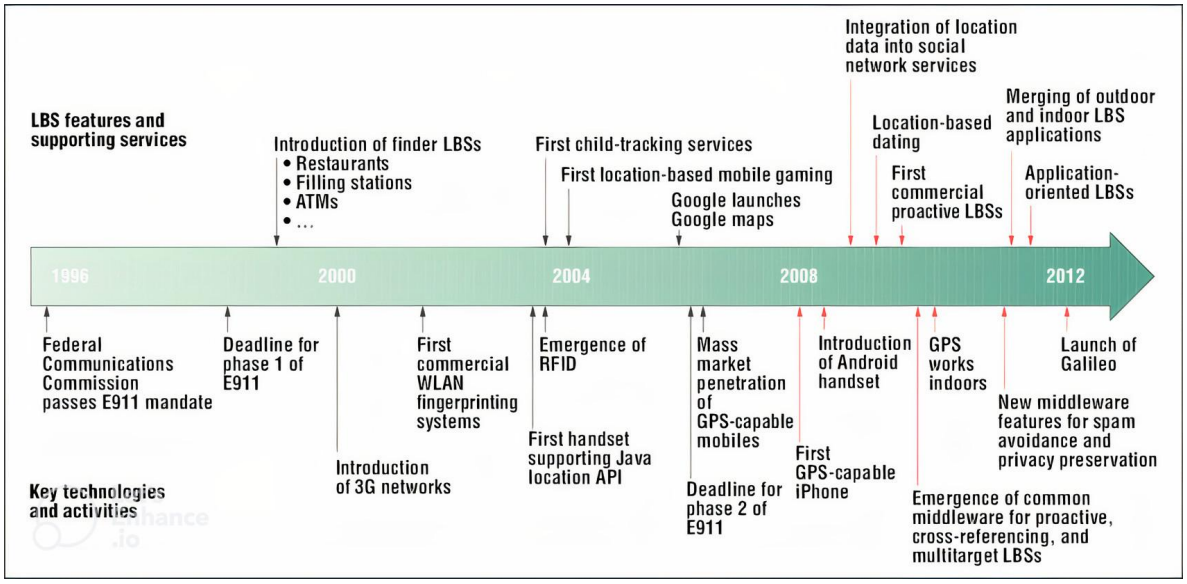

Figure1.5 : Evolution of Geolocation

1.2.3. Navigation

Tourism maps and station maps show the route to the destination, but it does not navigate the tourist step-by-step to the destination. Therefore, navigation is becoming the most major concern for tourists, tourism mobile applications started to put effort on bringing navigation to their applications. However, it is still seldom used by the society because of the imperfection of navigation feature. Some of them employ a navigation feature on their tourism applications by just simply showing out or switching to the Google Maps which is a general function used by other applications. It reflects the nonuser-friendly concern on these applications. The navigation feature does not actually fulfil the responsibility on

bringing the tourist to the preferred POI. They are just providing the almost similar function as the tourism board map or subway exit area map that showing the paths with a slightly differ of highlighting the selected POI's path. The non-user-friendly mobile applications are somehow giving a bad impression for the user on the tourism application and make them to uninstall these applications. Thus, the lifespan of these applications is very short. These tourists rather to use the navigation applications such as Waze and Google Maps, causing the tourism applications to become meaningless.

1.2.4. Maps

Maps serve as an essential tool in the tourism industry, providing travelers with an overview of the destination and its attractions. Maps aid travelers in navigating the area and planning their itinerary, while also serving as a promotional tool for tourism destinations. Thematic routes, such as cultural, culinary, or natural routes, can be created to allow tourists to explore specific aspects of the destination in greater depth. Moreover, maps can be used to highlight specific points of interest, such as museums, historic sites, or natural landmarks. They can also provide information on local customs, traditions, and cultural events to enhance the tourist experience and provide a unique and authentic experience for visitors.

Additionally, maps can be used to collect and analyze data about tourist behavior and preferences, helping tourism operators to design and market their products more effectively. By analyzing the data collected from maps, tourism operators can identify popular destinations, attractions, and activities, and use this information to improve their offerings and increase visitor satisfaction. This can ultimately lead to a better understanding of tourist behavior and preferences, leading to better marketing strategies, product development, and increased revenue for tourism destinations.

1.3. Problem Statement

The tourism industry has witnessed a significant growth in recent years with the emergence of technology-driven travel experiences. Augmented Reality (AR) has become an increasingly popular technology in various fields, including tourism. However, there is a lack of comprehensive research on the use of AR in travel applications. This major project aims to address this gap by developing an AR travel application that offers an innovative and immersive travel experience to users. The application will utilize AR technology to provide users with real-time information and visualizations of their surroundings, enhancing their travel experience and promoting engagement with local culture and history. This project will also investigate the effectiveness of the AR travel application in enhancing user experience, user satisfaction, and promoting sustainable tourism.

1.4 Proposed work

As the travel and tourism industry is growing, so is the need for innovative technology. One such technology that has emerged in recent years is AR. Augmented reality has the potential to revolutionize the travel and tourism industry by enhancing the user experience and providing interactive and immersive experiences. In this context, an AR travel application is proposed that will enable users to explore travel destinations in a whole new way.

The geolocation module is an essential component of any travel app. It allows users to navigate through their chosen destinations, locate points of interest, and receive directions to their desired locations. The application will utilize the Google Maps SDK for both iOS and Android platforms. The Google Maps SDK will provide a dynamic, interactive map to users that can be used offline without requiring an internet connection. The geolocation module will enable the application to determine the user's location in real-time and provide the user with relevant information about nearby tourist attractions, restaurants, and other points of interest.

The booking and buying services module will allow users to purchase tickets, book hotels, and reserve restaurants or other tourist attractions. This module will utilize APIs from various travel service providers to offer users a wide range of options for their travel needs. Users will be able to search for their desired travel destinations, select their preferred travel dates, and choose from a range of different travel service providers. This module will be integrated with popular payment gateways to allow users to make payments securely within the application.

The reviews and recommendations module will enable users to view reviews and ratings of tourist attractions, hotels, and other travel services. Users will be able to read reviews from other users who have visited a particular location and share their own experiences by leaving reviews. The application will allow users to filter reviews by different criteria such as location, category, and rating. The reviews and recommendations module will utilize APIs from various travel review websites such as TripAdvisor, Yelp, and Google Reviews.

Weather conditions can have a significant impact on travel plans. The weather forecasting module will provide users with up-to-date information on weather conditions for their chosen travel destinations. The module will utilize APIs from various weather services providers such as AccuWeather, OpenWeatherMap, and Weather.com to provide real-time weather updates to users. Users will be able to access information on temperature, precipitation, humidity, and wind speed, among other weather parameters.

The AR destination viewing module will allow users to view their travel destinations in augmented reality. This module will enable users to experience a virtual tour of their chosen travel destinations without physically being there. The application will use the Unity3D software development kit to build the AR feature, which will be embedded into the application using the ARCore plugin. Users will be able to switch to the AR mode by clicking a button on the application's interface. Once in AR mode, users will be able to view a 3D model of their chosen travel destination and explore it in a unique, interactive way.

The application will also provide users with a range of helpful utilities to make their travel experience more convenient. The helpful utilities module will include features such as a world clock, checklists, sharing of contact information, and a payment gateway. The world clock feature will allow users to view the current time in different time zones, making it easier to coordinate travel plans across different locations. The checklists feature will allow users to create a list of essential items to pack for their trip. The sharing of contact information feature will enable users to share their contact information with other users, making it easier to stay in touch while traveling. The payment gateway feature will allow users to make secure payments for travel services within the application.

In conclusion, the proposed AR travel application presents an innovative solution that has the potential to revolutionize the travel and tourism industry. The application is designed to provide users with an interactive and immersive experience that can greatly enhance their overall travel experience. The various modules of the application will work together to provide a seamless and intuitive user interface that can be easily navigated by users of all skill levels.

The proposed AR travel application leverages the latest technologies and frameworks to provide a smooth and responsive user interface that can support a wide range of features and functionalities. The use of cutting-edge technologies such as geolocation, augmented reality, and real-time weather forecasting will provide users with a highly engaging and personalized experience. The use of Google Maps SDK for iOS and Android will enable the app to provide users with offline maps, which is essential for travelers who may not always have access to the internet while on the go.

The AR destination viewing feature of the app is particularly noteworthy as it enables users to experience travel destinations in a whole new way. By simply clicking on the AR mode, users can enjoy an augmented reality experience that allows them to view travel destinations from different angles and perspectives.

The use of Unity3D software and ARCore plugin ensures that the AR feature is highly responsive and accurate, providing users with an immersive experience that they will never forget.

Overall, the proposed AR travel application has the potential to significantly enhance the travel experiences of users by providing them with a range of features and functionalities that are designed to make travel planning and exploration easier and more enjoyable. By leveraging the latest technologies and frameworks, the application is able to provide a smooth and seamless user experience that can cater to the needs of travelers of all ages and skill levels. With the proposed AR travel application, travelers can explore travel destinations in a whole new way, making their travel experiences more exciting and memorable.

1.5. Organization of Report

The report is structured as follows: The first chapter serves as an introduction, providing an overview of the problem at hand. This section encompasses various components that outline the details of the project. Subsequently, Chapter 2 delves into the Evolution of Technology, presenting an enumeration of the advancements and developments in the technology employed for this augmented reality travel application.

Moving forward, Chapter 3 entails a comprehensive discussion on the Algorithms and Modules utilized throughout the project, which were instrumental in achieving the specified objectives. Following this, Chapter 4 elucidates the Use Cases and Application of all the models elucidated in the previous chapter.

The penultimate section delves into an evaluation of the Merits and Demerits of the developed application, analyzing its real-world implications in Chapter 5. Lastly, Chapter 6 serves as the conclusion, encapsulating the findings and analysis conducted, and offering final reflections on the solution presented.

In summary, this paper adopts a structured approach to present the augmented reality travel application. It begins with an introduction, followed by an exploration of technological advancements. The subsequent chapters delve into the algorithms, modules, use cases, and applications of the developed models. The paper concludes with an assessment of the application's merits, demerits, and real-world potential, offering conclusive insights and reflections on the proposed solution.

CHAPTER 2
LITERATURE REVIEW

The travel and tourism industry has undergone significant changes in recent years, with the advent of digital technologies and the internet. These changes have led to the development of various systems that aim to improve the overall travel experience for customers. In this article, we will explore some of the existing systems in the travel and tourism industry and how they work.

- Booking and Reservation Systems:

  One of the most significant developments in the travel and tourism industry has been the rise of online booking and reservation systems. These systems enable customers to book and reserve accommodations, transportation, and other travel-related services online, without the need for a travel agent. Examples of such systems include Expedia, Booking.com, and Airbnb.

  These systems work by providing customers with a user-friendly interface that allows them to search for available options based on their preferences. Customers can filter their search results based on factors such as price, location, and amenities, among others. Once customers have found a suitable option, they can make a reservation and pay for the service online. These systems provide customers with greater control over their travel plans and enable them to save time and money.

- Travel Planning Systems:

  Another significant development in the travel and tourism industry has been the rise of travel planning systems. These systems provide tools for customers to plan their trips, including searching for destinations, creating itineraries, and finding attractions. Examples of such systems include TripAdvisor and Lonely Planet.

These systems work by providing customers with access to a wealth of information about various destinations, including reviews, photos, and ratings from other travelers. Customers can use this information to plan their trips based on their interests and preferences. These systems also provide customers with a range of tools for creating itineraries, finding attractions, and booking tours and activities.

- Payment and Financial Systems:
  Payment and financial systems play a crucial role in the travel and tourism industry, enabling customers to make secure online payments and manage their travel-related finances, including currency exchange and travel insurance. Examples of such systems include PayPal and WorldPay.

  These systems work by providing customers with a secure and user-friendly platform for making payments online. Customers can use these systems to pay for their travel-related services, including accommodations, transportation, and tours and activities. These systems also provide customers with tools for managing their travel-related finances, including currency exchange and travel insurance.

- Customer Relationship Management Systems:
  Customer relationship management (CRM) systems help businesses manage their customer interactions and improve customer satisfaction. Examples of such systems include Salesforce and Zoho CRM.

  These systems work by providing businesses with a centralized platform for managing customer data and interactions. Businesses can use these systems to track customer interactions, analyze customer behavior, and develop targeted marketing campaigns. These systems also provide businesses with tools for managing customer feedback and improving customer satisfaction.

- Tour Operator Systems:

  Tour operator systems enable tour operators to manage their tours and activities, including scheduling, bookings, and payments. These systems work by providing tour operators with a user-friendly platform for managing their tours and activities. Tour operators can use these systems to create and manage their tour schedules, take bookings online, and process payments. These systems also provide tour operators with tools for managing customer feedback and improving the quality of their tours.

- Destination Management Systems:

  Destination management systems are used by destination management organizations to promote their destinations, manage tourism-related data, and provide visitor information.

  These systems work by providing destination management organizations with a centralized platform for managing tourism-related data and promoting their destinations. These systems can be used to provide visitors with information about local attractions, accommodations, and events. These systems also enable destination management organizations to collect data on visitor behavior and preferences, which can be used to improve their marketing efforts.

- Global Distribution Systems:

  Global distribution systems (GDS) provides a centralized platform for travel agents to book and manage travel-related services for their customers. Examples of such systems include Amadeus and Sabre.

  These systems work by providing travel agents with access to a comprehensive database of travel-related services, including flights, hotels, car rentals, and tours and activities. Travel agents can use these systems to search for available options based on their customer's preferences and make reservations and bookings online. These systems also provide travel agents with tools for managing customer data and interactions, as well as tracking their commissions and earnings.

> The travel and tourism industry has undergone significant changes in recent years, driven by digital technologies and the internet. The development of various systems has enabled businesses to improve their operations, enhance the travel experience for customers, and increase revenue. From booking and reservation systems to destination management systems, each system plays a crucial role in the overall travel experience. As technology continues to evolve, we can expect to see further developments in the travel and tourism industry, enabling businesses to provide even better services to customers.

Several mobile applications have been developed to improve the tourism experience, with or without the use of AR. Their primary purpose is to aid travelers in dealing with various issues such as getting lost, lack of information, language barriers, and others, in order to enhance the level of convenience provided by the application. Four tourism mobile applications, including MapFan AR Eye, Dublin AR, ExplorAR, and mTrip Travel Guide, will be analyzed in-depth, as they have incorporated AR technology in two areas: navigation and local context. Furthermore, the study will examine current AR technologies, such as ARCore, Vuforia, and ARKit, to determine the most appropriate AR SDK for this project.

2.1. Applications

2.1.1 Dublin AR and ExplorAR

Dublin AR is an innovative mobile application designed to enhance the tourism experience in the Urban Heritage site by leveraging Augmented Reality (AR) technology. The project is a collaborative effort between the Dublin City Council, Manchester Metropolitan University, and Dublin Institute of Technology, with the aim of transforming Dublin, a city rich in heritage, into a modern and appealing AR city that can attract more visitors. By overlaying relevant tourism information, the application rejuvenates and retells historical narratives, creating a rich and immersive experience for tourists. Using AR, the application displays important information such as the name, rating, category and distance of

nearbyPoints of Interest (POIs) as depicted in Figure 2.1. In essence, Dublin AR is a mobile platform that facilitates the sharing of valuable tourism information.

Figure 2.1: Dublin AR mobile application user interface in the camera

ExplorAR is another mobile application focused on tourism that shares many similarities with the Dublin AR application mentioned previously. However, there is a key difference: ExplorAR is intended for merchants who wish to be included in the app, whereas the Dublin AR detects all points of interest in the city of Dublin. Merchants such as restaurants and shopping malls have the option to register themselves with the app, which then allows them to be visible within the application. (See Figure 2.2)

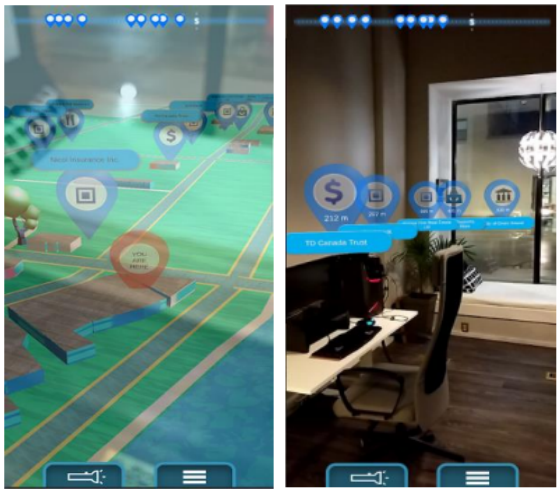

Figure 2.2:The user interface of ExplorAR

2.1.2 MTrip Travel Guide

The mTrip Travel Guide platform offers tourists the flexibility to modify their travel plans at any point, whether it's before, during, or after their trip. By selecting Points of Interest (POIs) and incorporating them into their itinerary, tourists can enhance their planning and manage their time more effectively (Yovcheva, Buhalis & Gatzidis, 2012). While mTrip's tour generation features initially drew users, the addition of AR features brought the application up-to-date without significantly setting it apart from others, such as Dublin AR and ExplorAR.

Another inconspicuous strength is the categorizing of POIs. Based on Figure 2.3, shows that the application separates the POIs into attractions, shopping, bar, restaurant, hotel, and others. Such strengths avoid the user from getting overloaded with information and undergoing visual clutter.

Figure 2.3: The user interface of mTrip

2.1.3. MapFan AR Eye

MapFan AR Eye is a navigation mobile application that can be used for tourism purposes developed by a Japanese software company known as Increment P Corporation. The applications operated through inputting a POI's name or address by the user to locate the POI and then, the user can start to navigate to the selected POI. A user can activate the AR navigation feature and begin to hold their phone to scan for the augmented path to navigate to the destination. During the navigation, it will display both the street view and the map simultaneously (see Figure 2.4). There will be a small vibration indicating the tourists had reached the destination. This application is built to support only IOS operating system devices. Such navigation features can act as a reference for the proposed application.

The dual navigation mode of MapFan AR Eye can provide a better visual direction to the user to the destination. The user can always keep track of their current location in either AR navigation or map navigation. Non-cross-platform compatibility of MapFan AR Eye is one of the reasons that this application remains unfamiliar and unpopular in worldwide.

Figure 2.4:The user interface of MapFan AR Eye

2.1.4. Some Related Works on Augmented Reality for Travel

Several related works on augmented reality for travel have been conducted. These include the development of a mobile application prototype for smart tourism that integrates augmented reality, image detection, and GPS, enabling social media analysis. Another project involved the creation of an app called AR City!, which combines location-based systems and augmented reality to enhance the tourist experience and enable interaction with the environment. Additionally, researchers have investigated the design and development of mobile applications for tourism that utilize image-based recognition augmented reality. Another app called iARTour allows users to scan image markers or text markers from a brochure, providing 3D models of tourist landmarks and offering a unique learning experience about Indonesian tourism. Finally, a location-based augmented reality mobile application was developed to engage tourists through game-based storytelling, creating interactive experiences at tourism sites.

Reference	Method	The platform, Software, or Libraries	Result
Demir and Karaarslan	Markerbased and GPS Augmented Reality	Android Studio, OpenCV	A mobile application prototype for smart tourism that uses Augmented Reality. Augmented Reality uses image detection and GPS, and the application provides social media analysis.
De La Nube Aguirre Brito	LocationBased systems Augmented Reality	Hybrid (Android and Web), Wikitude SDK	An app called AR City! was developed to find out the benefits of Augmented Reality for tourism. It uses Location-Based systems and Augmented Reality. Through the app, the tourists can interact with the environment and increase their experience on the site.

Chiu et al	Image-based recognition Augmented Reality	Vuforia SDK	Investigate the design and development of mobile applications for tourism. The app uses image recognition and AR.
Herumurti et.al	Image marker and text marker Augmented Reality	Android, Unity, Vuforia SDK	An app called iARTour. The users can see 3D models of a tourist landmark by scanning the image marker or text marker from a brochure.
Nobrega et al	Location-based Augmented Reality	Android, Unity	A game-based storytelling mobile application with Augmented Reality. It creates engagement between tourists and the urban environment, thus creating an experience and interactivity challenge for tourists on a tourism site.

Table 2.1: Related works on Augmented Reality Travel applications

Functionality	**MapFan AR Eye**	**Dublin AR**	**ExplorAR**	**MTrip Travel Guide**
Context-aware push	✗	✗	✗	✗
Feedback	✗	✓	✓	✓
Pedestrian navigation	✓	✗	✗	✗
Map services	✓	✓	✓	✓
Interactive AR view	✗	✗	✓	✗
Filtering of AR content	✗	✗	✗	✗

Table 2.2: Functionality of above Tourism Mobile Application

2.2. AR Technologies

2.2.1. Google ARCore

Google developed ARCore, an SDK that was released on March 1st, 2018. However, to utilize the ARCore SDK, the device needs to be included in Google's supported devices list. The cost of the SDK is free and it is available for use on Android and IOS platforms. ARCore incorporates 8 fundamental concepts, as stated on the official Google ARCore webpage. These concepts are used to seamlessly integrate virtual content with the real-world environment. The 8 fundamental concepts include motion tracking, environmental understanding, light estimation, user interaction, oriented points, anchors and trackable, augmented images, and sharing, according to Google Developers in 2019.

- **Motion Tracking**

  Using concurrent odometry and mappings (COM), ARCore's motion tracking technology can determine the phone's current location in relation to the world coordinates by analyzing the surrounding environment. Throughout the tracking session, a sparse point cloud consisting of feature points (as depicted in Figure 2.6) is captured via the camera and utilized to calculate the phone's changing position. The accelerometer and gyroscope data obtained from the Inertial Measurement Unit are then used to estimate the camera's orientation and position. This process enables ARCore to achieve accurate motion tracking. (Google ARCore, 2019).

- **Environmental Understanding**

  Plane detection is the process of identifying clusters of feature points on both horizontal and vertical surfaces, which results in the creation of a plane. This plane enables the placement of 3D objects and 2D annotations on flat surfaces, as demonstrated in Figure 2.5. For instance, using ArAnchor (Lanham, 2018), it is feasible to position a virtual doll on an actual bed.

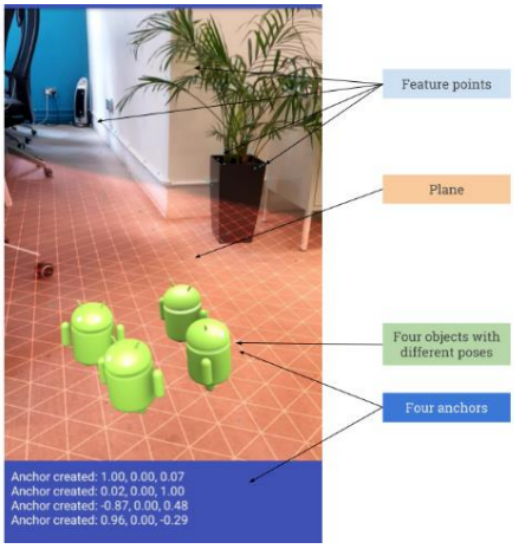

Figure 2.5:Example of feature points, plane, objects and anchors

- **Light Estimation**

  ARCore's light estimation utilizes the actual lighting in an environment to capture information on lighting conditions, such as average intensity and color correction. This data enables the system to distinguish between light and dark environments and display virtual objects accordingly. As illustrated in Figure 2.6, varying virtual objects can be presented in different lighting conditions.

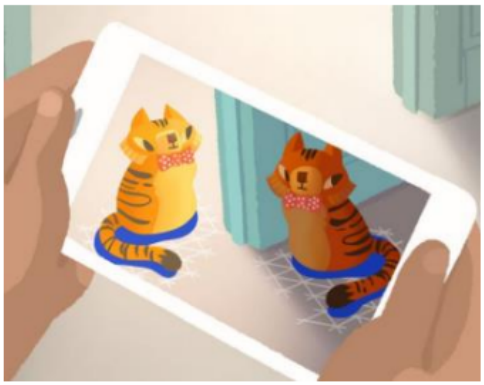

Figure 2.6: Lightning estimation of ARCore

- **User Interaction**

  In addition to allowing users to click on a plane or object to trigger desired outcomes, ARCore also offers other forms of user engagement. For example, the technology can recognize gestures, such as swipes or taps, to initiate actions within an augmented reality (AR) experience. To achieve this, ARCore uses machine learning algorithms to interpret user input and translate it into commands that the AR application can understand. This provides a more immersive and intuitive experience for users, allowing them to interact with AR content in a natural and intuitive way.

  Moreover, ARCore's sharing features facilitate multiple user interactions, allowing individuals to collaborate and experience AR content together. This can be particularly useful in educational or training contexts, where multiple users need to work together to complete a task or learn a skill. Overall, ARCore's advanced capabilities for user engagement and collaboration make it a powerful tool for creating immersive and interactive AR experiences.

- **Augmented Images**

  ARCore provides augmented images, which are a type of image marker tracking. By setting up the augmented images database, users can activate AR experiences when the camera detects a specific image that matches the database. In addition to static image tracking, ARCore also supports tracking of moving images.

- **Oriented Images**

  Oriented points are an essential component of augmented reality applications. They enable ARCore to accurately detect the location and orientation of real-world surfaces, which is crucial for creating seamless AR experiences. Feature points, in general, are key landmarks in the environment that ARCore uses to anchor virtual objects and animations in the real world.

- **Sharing**

  The purpose of sharing in ARCore is to allow the creation of collaborative and multiplayer apps for both Android and IOS device. In other words, different users can share the same AR experience through the device's camera although they are using different devices. The generated AR elements can be seen in all sharing devices. This creates the opportunity to perform multiple user interactions.

2.2.2. Vuforia

Vuforia is an augmented reality (AR) technology that focuses on tracking based on markers. It offers six different techniques for tracking, which include image target, model target, object target, multi-target, cylinder target, and vumarks. Each of these techniques is designed to enhance the user's tracking experience in different scenarios. The latest version of Vuforia, version 8.1, includes an advanced model target 360, which combines the popular trend of 360-degree camera views with AR. Compared to ARCore, Vuforia supports a wider range of devices, giving it a competitive advantage. There are both paid and free versions of Vuforia available, each designed for different users. The free SDK version of Vuforia is limited in features and is intended for educational purposes, while the paid version is required for commercial use. Vuforia Fusion makes it possible to combine ARCore, ARKit, and Vuforia technologies. Vuforia Fusion takes advantage of the strengths of each technology for different devices. For example, devices within the supported list will adopt ARCore or ARKit technologies, while Vuforia technologies will be used for devices not supported by ARCore or ARKit.

2.2.3. ARKit

Apple has created ARKit, an augmented reality (AR) technology that exclusively supports IOS devices. As a result, compared to other AR technologies available, the range of devices that ARKit supports is quite limited. Developers can integrate AR technology into their projects freely using ARKit. ARKit mainly focuses on three key areas to support AR: tracking, scene understanding, and rendering. Apple intends to incorporate additional features in future releases, allowing ARKit to compete more effectively in the AR market.

- **Tracking**

  ARKit includes two types of built-in tracking: orientation and world tracking. Orientation tracking uses the phone's internal sensors to determine its degree and rotation. On the other hand, world tracking goes beyond orientation tracking by incorporating the phone's physical location to create a virtual coordinate space known as a world map. This means that ARKit can not only determine the phone's orientation but also understand the user's movement, such as walking distance and direction (Axon, 2018).

- **Scene Understanding**

  ARKit's scene understanding feature enables the device to recognize various characteristics of the surrounding environment, such as the lighting conditions, surface textures, and angles. Through the use of this technology, plane detection can identify both horizontal and vertical surfaces, providing valuable information to developers when positioning virtual objects within a given world map.

- **Rendering**

  Once the tracking and scene understanding stages are complete, the final step in the AR process is rendering. This involves placing the 3D object in the desired location using either plane detection or image recognition. This contextual placement of 3D objects allows them to seamlessly blend into the scene as viewed through the device's camera.

2.2.4 Comparison of AR Technologies

	ARCore	**Vuforia**	**ARKit**
Platform	Android, IOS	Android, IOS	IOS
Device Supported	Medium	High	Low
Charges	Free	Free/Paid	Free
Image Tracking	Available	Available	Available
Stability	High	Medium	High
Markerless Tracking	Available	Unavailable	Available

Table 2.3: Comparison of the AR Technologies

As depicted in Table 2.4, ARCore is the most suitable AR technology for implementation in this project. While Vuforia supports more devices than ARCore, the latter offers free-of-charge implementation and better tracking stability. Additionally, markerless tracking is a crucial component for generating augmented arrows for AR navigation, which is not presently supported by Vuforia. ARKit has been disregarded as an option for this project due to its limited device compatibility with iOS only. Consequently, ARCore will be employed in this project.

Moreover, ARCore has been proven to provide excellent performance even in low-light environments, making it a suitable choice for scenarios where the lighting conditions are not ideal. It also offers robust motion-tracking capabilities, allowing virtual objects to remain anchored in the real world even as the user moves around. Overall, the selection of ARCore for this project is a well-justified decision, considering its suitability, ease of implementation, robust tracking capabilities, and a broad range of APIs and tools. With the help of ARCore, the project team can develop an AR navigation system that is stable, accurate, and engaging for the end-users.

CHAPTER 3
METHODOLOGY

Agile development methodology will be employed in this project. The reason of using this methodology is because of the user requirement may have changes over the whole development period (>1year) for this project. Agile development methodology divides the software developments into several short iterations called as Sprint that includes all SDLC phases, the planning, analysis design and implementation phases. Each functionality of the mobile application in this project is separated to different iterations. Each iteration will bring the application to adapt to different or latest user requirement and accumulate more functionality. Thus, it is suitable to a dynamic user requirement for a frequent redesign, incremental delivery and a higher customer interaction. It also reduces the chances of project failure as the application can be evaluated and getting feedback from the ending phases of each iteration. Activities to be done in each phase will be discussed in below. Figure 3.17 illustrate the flow of agile development.

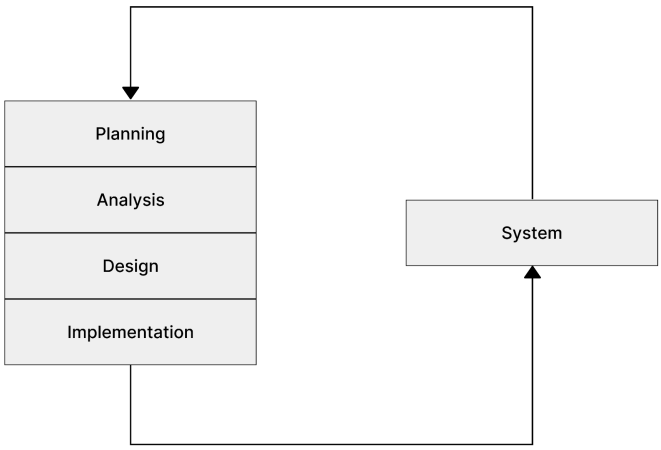

Fig 3.1 Agile Methodolgy

Planning

In the planning phase, the significant problems faced by the user in this tourism issue are identified. Brainstorming occurs to generate idea to solve these problems effectively. The project scope and objectives of the projects in solving the problems are determined to finalize the project deliverables for each iteration and the target user of this project is well-recognized. Time management through schedule with the help of gantt chart is built to allow the whole process of development application runs smoothly and efficiently. For this project, the idea of combining AR and tourism field in a mobile application is generated during the brainstorming and discussion with the supervisor.

Analysis

In the analysis phase, the user requirements of the application are gathered and analyzed. Research and survey will be carried out to collect the feedback of the current tourism mobile application and their possible advancement. The collected feedback is then being analyzed to determine the user requirement for the current iterations. For example, the study on the current tourism mobile application and AR technology is carried out to identify the possible user requirement in this project.

Design

In the design phase, the physical design of the system is being idealized according to the logical design of the system. The user interface of the application will be designed to handle the user requirements in an attractive GUI. The user interface will then become a sample for the implementation phase to develop the GUI. In this phase, the 5 modules of this project are being defined to act as a criterion for evaluation.

Implementation

In the implementation phase, the coding and programming activities of the application are carried out to fulfill the user requirements determined in the design phase. Before forwarding to the next iterations, it will undergo several testings to test whether the function of the application is well-design and meet the user requirements. Testing by downloading the project's application with the device or android emulator and trying out their functionality. A verification plan is going to be developed in this project to test each module' functionality.

Fig 3.2 Agile Methodology Phases

3.1 Project Implementation

3.1.1 Software Technology

3.1.1.1 ARCore

ARCore is chosen in this project because ARCore allows item such as icon, picture and etc. to be placed in the AR world using real-world GPS coordinates which is the longitude and latitude. Thus, the pictures of the POIs can be registered in line with the locations in this project. Motion tracking occurs with the movement of the phone itself and hence, the location of the user can be kept track along the navigation and the path to the preferred POI can be updated as well.

In order to possess the benefits of ARCore like environment understanding and motion tracking, ARCore API can be simply called to include in the application since it is a public source API (Riddick, 2018). It means that all the functionality of ARCore can be used, unlike the Vuforia SDK where it needs payment to be able to access to the full functionality.

3.1.1.2 Google Maps API

To retrieve the map and information of the Points of Interest (POIs) in your augmented reality travel application, you can integrate map services and utilize APIs such as the Google Maps API and Mapbox SDK. Here's an expanded explanation:

1. Map Services Integration: You can integrate map services into your application to display maps and related information. This involves retrieving map tiles, markers, and overlays to visualize the geographical data. Map services provide various functionalities to interact with the map, such as panning, zooming, and rotating.

2. POI Information Retrieval: To display information about POIs on the map, you can utilize APIs like the Google Maps API. This API allows you to retrieve details such as the operation status, address, photos, ratings, reviews, and other relevant data for the identified POIs. By fetching this information, you can present it to the user within your application's map services.

3. Autocomplete API: The Autocomplete API, part of the Google Maps API, can be utilized to enhance the search functionality in your application. It enables users to search for specific locations, addresses, or POIs by providing real-time suggestions as they type. This autocomplete feature simplifies the search process and improves the user experience by suggesting relevant options.

4. Navigation Functionality: While the Google Maps API provides navigation functionality, it typically redirects users to the official Google Maps application for turn-by-turn directions. This aligns with your proposed application's feature of leveraging the Google Maps app for navigation purposes. When users initiate navigation within your app, you can seamlessly transfer them to the Google Maps app for a full navigation experience.

5. Mapbox SDK for Navigation: To support the navigation function within your augmented reality travel application, you can integrate the Mapbox SDK. Mapbox offers a robust SDK with navigation capabilities, allowing you to provide in-app turn-by-turn directions, route calculations, and real-time navigation instructions. By incorporating the Mapbox SDK, you can provide a comprehensive navigation experience without relying solely on external applications.

By combining the Google Maps API for map display, POI information retrieval, and search autocomplete, and integrating the Mapbox SDK for in-app navigation, your AR travel application can offer seamless map services, rich POI information, and reliable navigation functionality to enhance the user experience.

3.1.1.3 Mapbox SDK for Android

The Mapbox SDK for Android is a powerful toolkit that enables developers to integrate map functionality into their Android applications. In addition to providing basic mapping features, the Mapbox SDK for Android offers a wide range of capabilities, including the ability to add navigation services to an application. Here's an expanded explanation:

1. Back-End Maps Data: The Mapbox SDK for Android handles the back-end map data, including data downloading and caching. This ensures that the necessary map data, such as tiles and vector layers, are efficiently retrieved and stored on the device. By managing these processes, the SDK ensures a smooth and seamless map experience for users.

2. Interaction and Gesture Handling: The SDK handles the response to map gestures, such as zooming, panning, and rotating. It provides built-in functionalities that allow users to interact with the map easily. These gestures enable users to explore and navigate the map intuitively, enhancing the overall user experience.

3. Navigation Services: One of the notable features of the Mapbox SDK for Android is its navigation capabilities. It provides tools and APIs to incorporate turn-by-turn navigation into your application. This allows you to create applications that offer real-time, voice-guided directions for users, making it easier for them to navigate through different locations.

4. Customization and Design: The Mapbox SDK for Android enables you to modify the design and appearance of the map and navigation components to match your application's branding and user interface. You can customize map styles, colors, labels, markers, and other visual elements to create a consistent look and feel across your application.

5. Integration with Other APIs: The Mapbox SDK for Android integrates well with other APIs and services, allowing you to extend its functionality and enhance your application. For example, you can combine the navigation features with location-based services, such as geocoding or place search, to provide users with a comprehensive travel experience.

6. Advantages over Google Maps API: While the Google Maps API is widely used and offers robust mapping capabilities, the Mapbox SDK for Android can provide certain advantages, especially in terms of navigation. Mapbox's navigation services are designed to offer a seamless, customizable, and user-friendly navigation experience. Additionally, Mapbox's SDK allows for more extensive customization and control over the map design, allowing you to tailor the navigation experience to your specific application requirements.

By utilizing the Mapbox SDK for Android, developers can leverage its comprehensive mapping features, navigation services, customization options, and seamless integration with other APIs to create engaging and feature-rich travel applications with enhanced navigation capabilities.

3.1.1.4 Android Studio

Android Studio is utilized for creating the user interface (UI) of the system, specifically for components that do not involve augmented reality (AR) functionalities. This includes scenes like the tutorial, homepage, and offline map services. The choice of Android Studio for UI design is based on the ease of use offered by the IDE, allowing for intuitive drag and drop designs. In contrast, Unity requires more extensive efforts to achieve a similar UI compared to Android Studio. Consequently, the UI design created in Android Studio will be seamlessly integrated with the AR features developed in Unity.

3.1.1.5 Unity

Unity is an integrated development environment (IDE) that serves as one of the standard programming environments for AR applications. It offers a wide range of features and tools specifically tailored for game development and 3D projects.

Unity's strength lies in its ability to handle 3D-related projects. It provides a robust set of tools for designing and creating 3D assets, scenes, and animations. For our tourism AR mobile application, we will use Unity to develop the 3D augmented reality figures, such as arrows, pictures, icons, and other visual elements that enhance the AR experience.

Unity's compatibility with ARCore allows for seamless integration with Android devices. ARCore is a platform developed by Google that provides AR capabilities for Android devices. By integrating Unity with ARCore, we can leverage the power of both tools to build interactive and immersive AR experiences.

The integration between Unity and ARCore allows us to create 3D AR figures and control their settings through the C# programming language. Unity uses C# as its primary scripting language, providing a familiar and powerful environment for coding interactive AR elements.

Once we have built the AR-related works, including the 3D AR figures, within Unity, we can export the project to Android Studio. Android Studio is the official integrated development environment for Android app development. It allows us to fine-tune the UI design, add additional features, and handle other aspects of the Android platform-specific functionality.

By integrating the exported project from Unity into Android Studio, we can combine the AR functionality and UI design to create a complete system for our tourism AR mobile application. This integration ensures that the AR figures and other features seamlessly blend with the overall application experience, providing a cohesive and engaging user interface.

3.1.1.6 Flutter

We can use Flutter to develop the user interface and logic for your augmented reality (AR) travel application, while leveraging existing AR libraries and frameworks. Here's how we can utilize Flutter in the development of your AR travel app:

1. User Interface (UI) Development: Flutter provides a rich set of UI components and customizable widgets that we can use to design and build the interface for your AR travel app. We can create screens, navigation menus, buttons, and other visual elements using Flutter's widget system, ensuring a consistent and visually appealing user experience.

2. AR Integration: While Flutter itself does not have built-in AR capabilities, we can integrate Flutter with AR libraries or frameworks to incorporate AR functionality into your app. This involves using platform-specific AR SDKs, such as ARKit for iOS or ARCore for Android, and creating bridges between Flutter and the AR frameworks.

3. Platform-Specific AR Plugins: Flutter allows us to write platform-specific code using Swift/Objective-C for iOS or Java/Kotlin for Android. We can leverage AR SDKs and plugins specific to each platform to access AR features directly from your Flutter app. This enables us to utilize the full power of the native AR capabilities on iOS and Android.

4. 3D Object Rendering: Flutter supports 2D and 3D graphics rendering, which we can utilize for displaying 3D models and animations in your AR travel app. We can use Flutter's rendering capabilities or integrate external libraries like Unity3D to handle the rendering and manipulation of 3D assets.

5. Device Features and Sensors: Flutter provides plugins that allow us to access device features and sensors required for AR functionality. We can use Flutter plugins to access the device's camera, GPS, motion sensors, and other hardware capabilities needed for AR experiences. These plugins enable interaction with the device's sensors and provide real-time data for creating interactive AR elements.

6. Networking and Cloud Services: If your AR travel app requires cloud-based AR functionalities like object recognition or location-based AR experiences, Flutter can handle the networking and communication aspects. We can utilize Flutter's networking capabilities to connect with cloud-based AR services or APIs, retrieving relevant data and integrating it into your AR app.

7. Testing and Deployment: Flutter provides a comprehensive suite of testing tools that can help us verify the functionality and performance of your AR travel app. We can use Flutter's testing framework, along with its extensive testing documentation, to write unit tests, integration tests, and UI tests. Once your app is ready, Flutter allows us to easily deploy your AR travel app to iOS and Android devices, as well as web platforms.

3.1.2 Hardware Techonolgy

The hardware used for our augmented reality (AR) travel application will depend on the specific requirements and capabilities of the app. Here are some hardware components commonly used in AR applications:

1. Smartphones and Tablets: We can develop AR travel applications for smartphones and tablets, leveraging their built-in features such as cameras, GPS, gyroscopes, accelerometers, and display screens. These devices are widely accessible and provide a portable and interactive AR experience.

2. Head-Mounted Displays (HMDs): HMDs, such as augmented reality glasses or virtual reality headsets with AR capabilities, offer a more immersive AR experience. Examples include Microsoft HoloLens, Magic Leap, or devices compatible with platforms like Apple's ARKit or Google's ARCore. HMDs can provide hands-free interactions and overlay digital content onto the user's view of the real world.

3. Wearable Devices: Wearable devices, such as smartwatches or smart glasses, can provide a convenient way to access AR travel app features and receive notifications or contextual information. These devices can be used to display information, navigation directions, or notifications related to the travel experience.

4. Sensors and Tracking Devices: To enhance the AR experience, we can utilize additional hardware sensors or tracking devices. For example, depth sensors, LiDAR scanners, or external cameras can provide more accurate object tracking and environmental understanding, enabling better AR interactions and effects.

5. Beacons and Location Tracking: We can leverage hardware such as beacons or GPS trackers to enhance the location-based features of your AR travel app. These devices can provide precise location data, enabling augmented reality experiences that are specific to certain geographic locations or landmarks.

6. External Cameras and Accessories: In some cases, we might use external cameras or accessories to capture higher-quality video or images for AR content creation or advanced tracking. These devices can provide better image quality and more precise tracking data, resulting in more realistic and accurate AR experiences.

It's important to note that the hardware requirements and compatibility may vary depending on the targeted platform (iOS, Android, etc.) and the specific features and functionalities of our AR travel application. When developing our app, we will consider the hardware capabilities of our target audience and ensure that our app's requirements align with the devices commonly used by our users.

3.1.3 User Requirements

3.1.3.1 Hardware Requirements

The following describes the hardware needed in order to execute and develop an augmented reality travel application:

- Computer Desktop or Laptop

  The computer desktop or laptop will be used for building the application.

  The system must have:

  - 64-bit Microsoft Windows 8/10/11
  - X86_64 CPU architecture; 2nd generation Intel Core or newer, or AMD CPU with support for a Windows Hypervisor
  - 8 GB RAM or more
  - 8 GB of available disk space minimum

- Smartphones
  - iOS player requires iOS 9.0 or higher.
  - Android: OS 6.0 or later; ARMv7 CPU with NEON support or Atom CPU; OpenGL ES 2.0 or later.

3.1.3.2 Software Requirements

Software	Requirements
ARCore	1.10+ or newer version
Android Version	7.0+ (Nougat) or newer version

Table 3.1 Software Requirements for users

For the software requirements, the device has to be able to support the ARCore that can be found in the Google Play Store (see Table 3.1). As long as the device is within the device supported list of ARCore, the proposed application can work perfectly.

3.1.3.3 Connectivity Requirements

Connectivity	Requirements
Wifi/Data Connection	Recommended
Bluetooth	Not Required
GPS Service	Recommended

Table 3.2 Connectivity requirements for users

As table 3.2 shown, both WiFi/Data connection and GPS service are not an essential requirement to use this application. The application is workable in an offline status with a limited number of features. However, GPS service is required for the pedestrian navigation feature as it will provide the location information for the application so that the feature is able to function well. WiFi/Data connection is recommended as well when using the pedestrian navigation feature to improve the accuracy of the location information as it can help to retrieve the longitude and latitude data from Geolocation API.

3.1.4 System Design

In this project, it consists of 5 modules, which are the tutorial module, map service module, AR objects generator module, navigation module and POI information module. Each of the modules are represented in block, use case, activity, flow chart diagram.

Tutorial Module

This module serves the responsibility to guide the user on how to operate and utilize each function of the application. Different scenes for the tutorial must be designed in a meaningful and understandable way that allows user to perform the similar action by knowing the outcomes showed in the scenes. Furthermore, the ability to skip tutorials is provided for the experienced users. This module will utilize the fragment to complete and simplify into 3 fragments to reduce the wordy of the application.

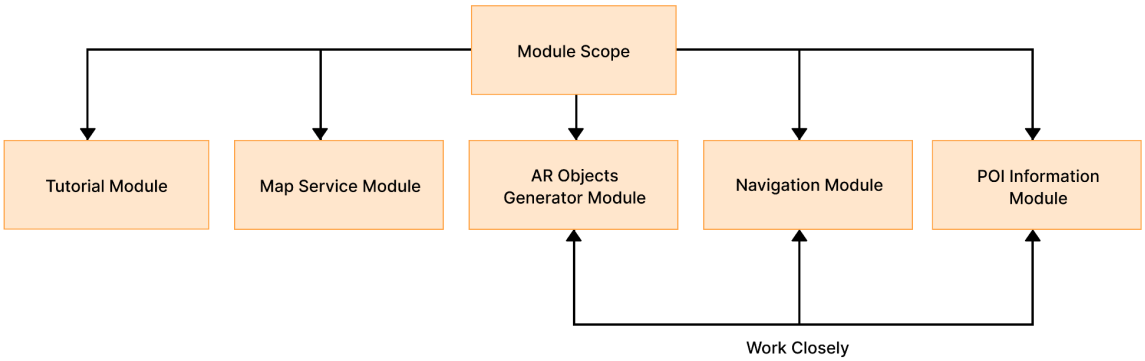

Fig 3.3 Modules of the project

Map Service Module

Upon the selection of the maps within the application, the corresponding map service will be shown and the basic functions of map service such as highlighting POI, providing POI information, route direction and distance estimation is offered. This module will work closely with the navigation module. This module will apply the Google Maps API to provide the map service. The map service includes the search, autocomplete and place API.

AR Objects Generator Module

As AR technology is one of the main selling points for this project, it becomes important to carefully manage each of the AR objects to be generated. Hence, this module will take care of the AR objects such as the 2D pictures, POI information board and arrows to be shown in the device. Showing these AR objects according to the category chosen is part of this module's responsibility. This module will act as a supporting module to provide AR objects to navigation module and POI information module. In order to generate the AR objects, ARCore will be used for the purpose of tracking and aligning.

Basic concept:

```
If (scanningImage == imagedatabase)
{
        If(imagedatabase.index == 0)
        {
                Relevance GameObject of the POI pictures appears above the scanning
            image.
        }

        Else

        {
        The GameObject will not appear.
        }

}
```

Navigation Module

Navigation module handles both normal and AR navigation. With the GPS data provided by the user, route direction to destination is generated. For normal navigation, the route will appear in the map service while for the AR navigation, augmented arrows will appear in the screen instead. Due to the limitation of Google Maps API in term of navigation, Mapbox SDK is used in this module instead to provide the both AR and non-AR navigation.

Basic concept:

```
If (origin is detached from the route)
{
        New route generated
}
```

Displaying the information of POI based on the user selection is to be worked over in this module. Retrieving the correct information corresponds to the selected POI so that the user can gain the accurate and updated information regarding the POI. Information such as operation hours, discount, menu, rating, brief description will be shown. For displaying the information of POI in AR mode, the information is required to be organized systematically inside a picture. Then, the picture contained with the information will appear in an AR form by using ARCore tracking technology.

Basic concept:
AR pictures is clicked.
switch(name of the clicked AR picture)

```
{
        Case “ABC restaurant”: ABC restaurant additional information appears in
        AR form. Break;
        Case “Penang Hall”: Penang Hall additional information appears in AR
        form. Break;
}
```

The switch case goes on until all POI is covered.

The project for the augmented reality travel application follows a three-layered architecture, ensuring a structured and efficient system design. Each layer has specific responsibilities and contributes to the overall functionality and user experience of the application.

1. Presentation Layer:

The presentation layer represents the user interface (UI) of the application. It is responsible for providing an intuitive and visually appealing interaction platform for users. In this layer, all the components that users see and interact with, such as screens, menus, buttons, and visual elements, are designed and implemented. The goal is to create a seamless and engaging user experience by incorporating AR elements, interactive maps, and informative visuals that enhance the travel experience. The presentation layer works in tandem with the underlying application layer to ensure the smooth flow of information and user inputs.

2. Application Layer:

The application layer serves as the backbone of the AR travel application, controlling its overall functionality. It handles various system operations and implements the core features and services of the application. This layer encompasses functionalities such as user authentication and authorization, geolocation services, booking and reservation management, and other essential operations. It integrates with external APIs and databases to retrieve and process data, providing users with relevant and up-to-date information for their travel needs. The application layer acts as the control center, coordinating different components and services to deliver a cohesive and efficient travel application.

3. Data Layer:

While not explicitly mentioned in the provided paragraph, the three-layered architecture typically includes a data layer responsible for managing data storage, retrieval, and persistence. The data layer encompasses databases, file systems, or any other form of data storage. It facilitates the secure storage of user information, travel data, geolocation data, and other relevant data required by the application. The application layer interacts with the data layer to retrieve and update information as needed, ensuring data integrity and consistency throughout the application.

By adopting a three-layered architecture, the augmented reality travel application separates concerns, promotes modularity, and facilitates easier maintenance and scalability. The presentation layer focuses on providing an appealing and user-friendly interface, while the application layer handles the core functionality and services. The data layer ensures efficient data management and storage. Together, these layers contribute to a robust and well-structured application design that enhances the user experience and supports the seamless integration of augmented reality and travel-related features.

3.1.5 Use case diagram

A use case diagram represents the interactions between actors (users or external systems) and the system itself, showcasing the functionalities and actions that can be performed within the application. Here's a description of a use case diagram for our AR Travel app:

1. Actors:

- User: The primary actor who interacts with the AR Travel app to access travel information, book services, and utilize AR features.
- Administrator: An optional actor responsible for managing and maintaining the app's backend, user accounts, and content.

2. Use Cases:

- Login: The user logs into the AR Travel app to access personalized features and content.
- Explore Destinations: The user searches for travel destinations, landmarks, or points of interest using the AR Travel app.
- View Location Information: The user can view detailed information about a specific location, including descriptions, ratings, reviews, and images.
- Geolocation Services: The app utilizes geolocation services to provide real-time location tracking and navigation assistance to the user.
- Book Services: The user can book various travel-related services such as flights, accommodations, tours, or car rentals through the app.
- Augmented Reality View: The user activates the augmented reality mode to overlay digital information, such as directions, historical facts, or virtual tour guides, onto the real-world environment.
- Save Favorites: The user can save favorite destinations, landmarks, or points of interest for quick access and future reference.
- Review and Rating: The user can provide feedback, ratings, and reviews for visited locations or booked services.
- Notifications: The app sends notifications to the user regarding special offers, updates, or relevant travel information.

- Manage User Profile: The user can update their personal information, preferences, and notification settings within the app.
- Administrator Management: The administrator can manage user accounts, content updates, and app configurations (if applicable).

3. Relationships:
- Association: The user is associated with all the use cases, indicating their interaction with the system.
- Include: The "Login" use case includes the "Manage User Profile" use case, as the user needs to be logged in to manage their profile.

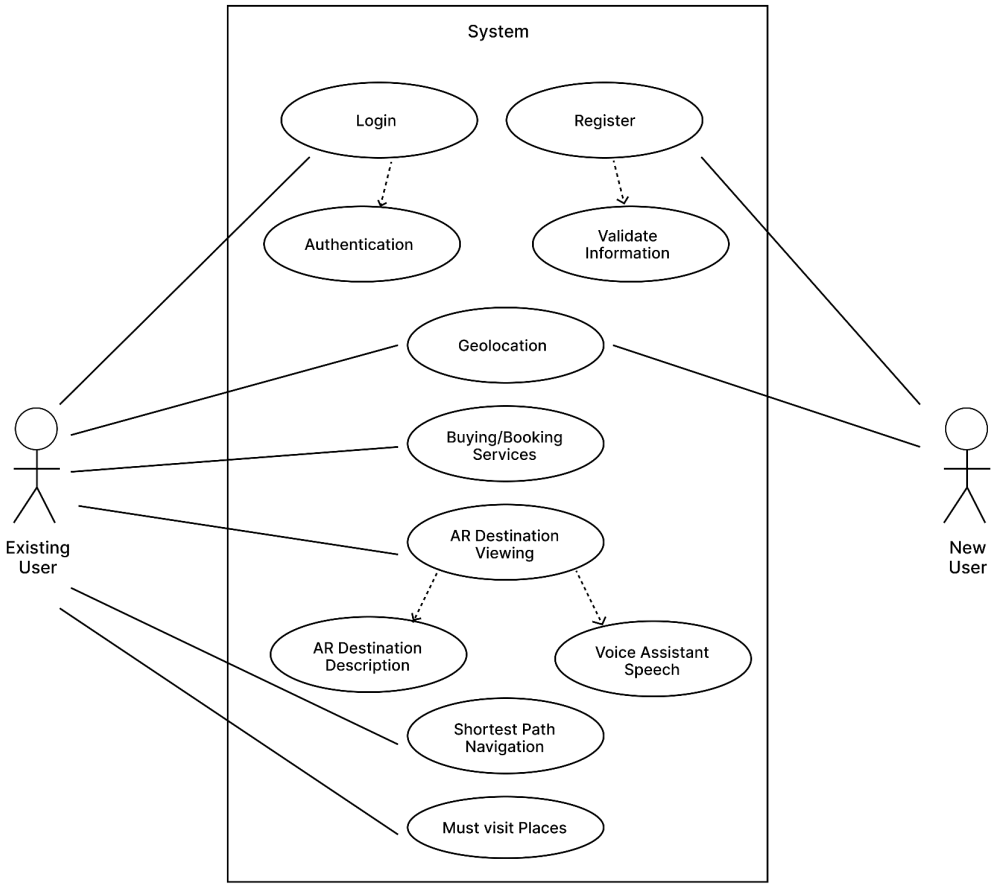

Fig 3.4 Use Case Diagram for AR Travel Application

3.1.6 Activity Diagram

Tutorial Module

Every time the user launches the application, when the user selects the start tutorial option, a series of tutorial UI scenes will be displayed, and user is required to either select next or previous to move to associated scene. Once the last UI scene is generated, the user can end the tutorial and move on to the main page UI of the application.

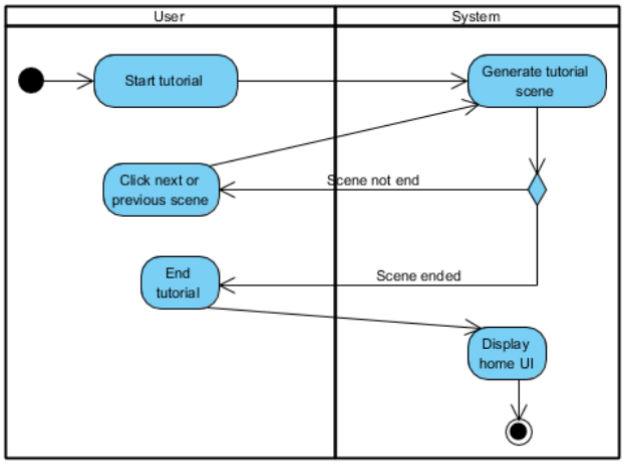

Fig 3.5 Activity diagram for start tutorial use case

Map Service Module

The user can select the map within the application and the system will retrieve the selected offline map.

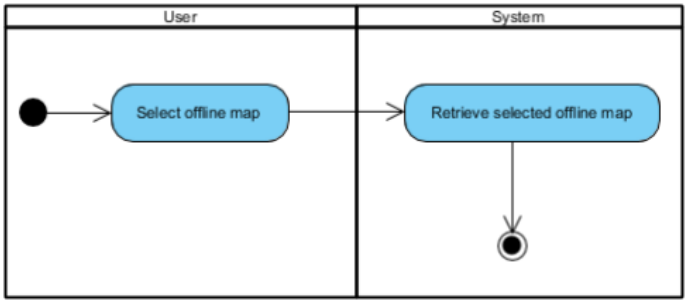

Fig 3.6 Activity diagram for select offline map use case

AR Objects Generator Module

The user scans the real map object and the system will keep tracking the scanning image with the ARCore image database. If the scanning image is matched, AR objects will be generated. Otherwise, the user is required to continue scanning.

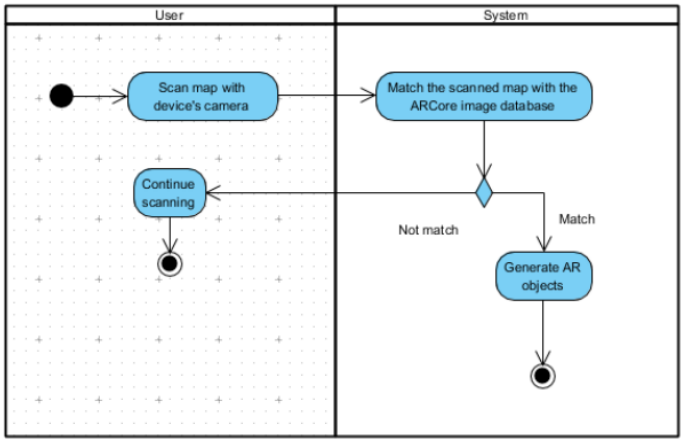

Fig 3.7 Activity diagram for scan map with device's camera use case

Select POIs' Category

For both maps either obtained from the scanning or within the application, the user can interact with the map by selecting the category of POI such as hotel, restaurant, entertainment and etc. Each category selected will be directed to the system to show the only POI that suits the category.

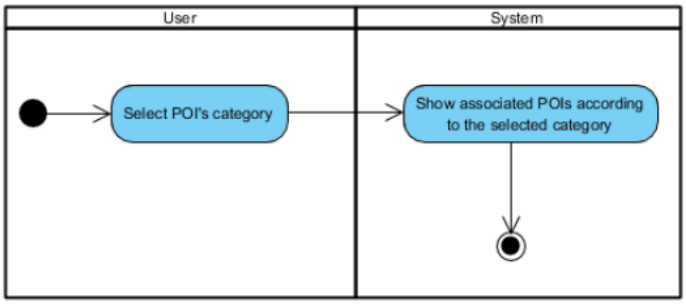

Fig 3.8 Activity diagram for select POIs' category use case.

Navigation Module

In navigation module, once the user retrieves the direction of the POI, the system will check the current GPS data of the user. With the GPS data, route direction is generated and displayed to the user in the map service. If the user actives the AR mode, augmented arrows will be displayed instead. The tracking process of GPS data is continued until the user reach the destination. In case of offrouting happens, the system will determine the new route to the destination.

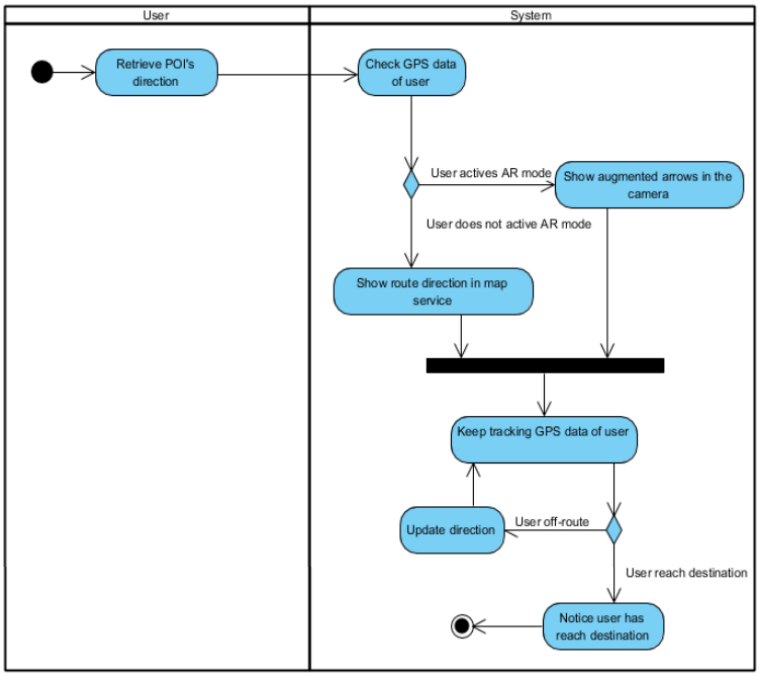

Fig 3.9 Activity diagram for retrieve POI use case

3.2 Feasibility Report

The purpose of this feasibility report is to assess the viability and potential success of developing an augmented reality (AR) travel application. The application aims to enhance the user's travel experience by providing real-time information, interactive maps, and immersive AR features.

During our preliminary investigation at college (Department of Computer Science), we examined the entire affair concerned with whether the information is technical, economical, and operationally feasible or not. The proposed system is reviewed considering four feasible studies, which are as follows:

- Economical Feasibilty
- Technical Feasibility
- Operational Feasibility
- Market Feasibility

3.2.1 Economical Feasibility

The economic feasibility study plays a crucial role in assessing the financial viability of the proposed augmented reality travel application. It involves a comprehensive evaluation of the costs involved in developing, deploying, and maintaining the application, as well as the potential revenue streams and financial benefits that can be derived from it.

1. Development Costs: The economic feasibility analysis begins by estimating the initial investment required to develop the AR travel application. This includes costs associated with hiring skilled developers, acquiring necessary software licenses, and obtaining AR development tools and frameworks. Additionally, expenses related to designing the user interface, creating content, and conducting testing should be taken into account. By carefully estimating these costs, the project's financial feasibility can be determined.

2. Ongoing Maintenance Expenses: Once the application is developed and deployed, ongoing maintenance and support costs must be considered. This includes expenses related to bug fixes, updates, server hosting, and technical support. It is essential to anticipate these

costs over the application's expected lifecycle to ensure its sustainability and uninterrupted functionality. By analyzing the ongoing maintenance expenses, the financial feasibility of sustaining the application in the long term can be assessed.

3. Revenue Streams: The economic feasibility study also involves identifying potential revenue streams that can be generated through the AR travel application. This may include various monetization strategies, such as in-app purchases for premium features, advertisements, partnerships with travel agencies, or subscription models. Market research and analysis can help determine the most suitable revenue models based on the target audience, competition, and market trends. By estimating the potential revenue generation from these streams, the viability of the application can be evaluated.

4. Cost-Benefit Analysis: A crucial aspect of economic feasibility is conducting a comprehensive cost-benefit analysis. This analysis compares the expected costs and benefits associated with developing and maintaining the AR travel application. It helps in quantifying the financial gains and determining whether the potential return on investment justifies the initial and ongoing expenses. By considering factors such as market demand, competition, pricing strategies, and revenue projections, a realistic assessment of the project's financial feasibility can be made.

5. Funding and Financial Resources: The economic feasibility study also considers the availability of funding sources and financial resources required to support the project. This involves exploring options such as self-funding, seeking investment from venture capitalists or angel investors, or securing grants or loans. Evaluating the availability and feasibility of these funding sources is essential to ensure that the financial requirements of the project can be met.

A comprehensive economic feasibility analysis provides insights into the financial viability of the augmented reality travel application. By assessing the development costs, ongoing maintenance expenses, potential revenue streams, and conducting a cost-benefit analysis, a realistic assessment of the project's financial feasibility can be made.

3.2.2. Technical Feasibility

The technical feasibility study plays a crucial role in assessing the viability of implementing the AR travel application from a technological standpoint. It involves a detailed analysis of various technical aspects to ensure the successful development, deployment, and maintenance of the application.

a) Hardware and Software Requirements: One of the key considerations is evaluating the hardware and software requirements for the AR travel application. This includes assessing the capabilities and compatibility of mobile devices that will support the application. It is essential to determine if the required features, such as cameras, sensors, and processing power, are available in a wide range of devices. Compatibility with different operating systems, such as Android and iOS, should also be taken into account to ensure broad accessibility for users.

b) AR Development Tools and Frameworks: The availability and suitability of AR development tools and frameworks are critical in determining the technical feasibility of the application. Tools like ARCore for Android and ARKit for iOS provide the necessary APIs and functionalities for creating immersive AR experiences. Assessing the maturity, documentation, and community support of these tools is essential to ensure smooth development and troubleshooting processes.

c) Development Resources and Expertise: A comprehensive evaluation of development resources and expertise is necessary to gauge the technical feasibility of the AR travel application. Skilled developers proficient in AR development, mobile app development, and UI/UX design will be required to bring the application to life. Considerations should be given to the availability of such resources within the organization or the feasibility of acquiring external expertise. It is crucial to ensure that the development team possesses the necessary skills and experience to effectively utilize the chosen AR development tools and frameworks.

d) Stability, Performance, and Security: The stability and performance of the AR travel application are vital for providing a seamless and immersive user experience. Thorough testing and optimization should be carried out to ensure that the application performs well across various devices and under different network conditions. Additionally, security measures should be implemented to protect user data and ensure the application's integrity.

e) Scalability and Future Growth: The technical feasibility study should also consider the scalability of the application to accommodate future growth and updates. Evaluating the architectural design, flexibility, and extensibility of the application will help determine its ability to handle increased user loads and accommodate new features or integrations.

By conducting a comprehensive technical feasibility study, potential technical challenges and limitations can be identified early in the project lifecycle. This allows for appropriate mitigation strategies and planning to ensure the successful development and deployment of the AR travel application.

3.2.3 Operational Feasibility

Operational feasibility plays a crucial role in determining the success of implementing an augmented reality (AR) travel application. This aspect of the feasibility study focuses on assessing whether the proposed system can be effectively integrated into existing operations and workflows. Several factors need to be considered to ensure operational feasibility:

a) Resource Availability: Evaluate the availability of necessary resources, both human and technological, required for the development and maintenance of the AR travel application. This includes skilled developers proficient in AR technology, UI/UX designers, and project managers. Additionally, assess the availability of required hardware and software infrastructure to support the application.

b) Impact on Current Workflows: Determine how the introduction of the AR travel application will impact existing processes and workflows within the organization. Consider potential changes or adjustments that need to be made to accommodate the new system. Assess any potential disruptions or challenges that may arise during the integration phase and develop mitigation strategies accordingly.

c) User Adoption: Analyze the potential acceptance and adoption of the AR travel application by its intended users, such as travelers, tour guides, or travel agencies. Conduct user surveys or focus groups to gather feedback and insights regarding user expectations, preferences, and any potential resistance to adopting the new technology. Understanding user needs and addressing their concerns will enhance the chances of successful implementation.

d) Technical Support and Training: Evaluate the technical support required to ensure the smooth operation of the AR travel application. Consider the need for a dedicated support team or helpdesk to address user queries and troubleshoot technical issues. Additionally, plan for comprehensive training programs to familiarize users with the features and functionalities of the application. Providing adequate technical support and training will contribute to the effective utilization of the system.

e) Scalability and Future Growth: Assess the scalability of the AR travel application to accommodate future growth and expansion. Consider factors such as increasing user demand, potential feature enhancements, and integration with additional travel services or platforms. Plan for scalability by selecting flexible and scalable technologies, designing a modular architecture, and establishing a roadmap for future updates and improvements.

By thoroughly evaluating the operational feasibility, potential challenges can be identified and appropriate strategies can be devised to overcome them. This ensures that the AR travel application can be seamlessly integrated into the existing operations, aligning with the organization's goals and objectives while delivering an enhanced travel experience to users.

3.2.4 Market Feasibility:

The market feasibility study focuses on assessing the potential success and acceptance of the AR travel application within the target market. It involves analyzing market trends, customer preferences, competition, and potential demand for such a product. By evaluating these factors, we can determine the market's readiness for an AR travel application and identify opportunities for differentiation and competitive advantage.

a) Market Trends and Dynamics: An in-depth analysis of market trends is crucial to understand the current landscape and anticipate future developments. This includes identifying emerging technologies, consumer behaviors, and travel industry trends that can impact the adoption and success of an AR travel application. By staying informed about market dynamics, it becomes possible to align the application's features and offerings with evolving customer expectations.

b) Target Audience and User Preferences: Defining the target audience is essential in assessing market feasibility. Determine the primary users of the AR travel application, such as adventure travelers, city explorers, or tourists, and understand their preferences, needs, and pain points. Conduct market research, surveys, or user interviews to gain insights into their expectations regarding AR experiences, travel information, and interactivity. This information will help tailor the application's features to meet their specific requirements.

c) Competitive Analysis: An in-depth assessment of existing AR travel applications and potential competitors is crucial for market feasibility. Identify direct and indirect competitors, their strengths, weaknesses, and unique selling points. Analyze their user base, pricing models, marketing strategies, and customer feedback to understand the competitive landscape. This analysis will enable the identification of gaps in the market that can be targeted by the AR travel application.

d) Value Proposition and Differentiation: Clearly defining the unique value proposition of the AR travel application is essential to stand out in the market. Identify key differentiators, such as innovative AR features, user-friendly interfaces, personalized recommendations, or partnerships with travel agencies. Emphasize the benefits and advantages that users will gain from using the application, highlighting how it enhances their travel experiences and provides valuable information in real-time.

e) Market Size and Potential Demand: Estimating the market size and potential demand for an AR travel application is crucial for market feasibility. Analyze travel industry reports, tourism statistics, and user data to assess the addressable market and identify the potential user base. Consider factors such as demographic trends, travel preferences, and the growing adoption of mobile applications to project the potential demand and user acquisition prospects.

The market feasibility study is a critical component in determining the success of the AR travel application. By analyzing market trends, understanding user preferences, evaluating competition, and assessing potential demand, we can gain valuable insights into the market's readiness and identify opportunities for differentiation. This information will help shape the application's features, marketing strategies, and target audience, increasing the chances of capturing a significant market share. Conducting thorough market research and remaining adaptable to evolving market dynamics will ensure the application's viability and potential for long-term success.

3.3 Testing Analysis

A comprehensive testing strategy is crucial to ensure the quality, functionality, and usability of the augmented reality travel application. It involves various testing approaches and techniques to identify and rectify any issues or bugs. Here are some key testing modules and considerations for the application:

1. Functional Testing:
Functional testing focuses on verifying the application's intended functionality. It involves testing each feature and interaction to ensure they work as expected. Key functional testing modules for the AR travel application may include:
- User authentication and registration
- Geolocation services and map functionality
- Booking and reservation management
- AR visualization and tracking
- Integration with third-party APIs (e.g., payment gateways, travel services)

2. User Interface Testing:
User interface testing ensures that the application's visual elements, navigation, and overall user experience meet the desired standards. This module includes:
- Testing the layout and responsiveness of UI components across different devices and screen sizes
- Verifying the consistency of design elements and branding
- Checking the accessibility and ease of use of the application, especially for users with disabilities
- Testing the responsiveness of user interactions and gestures in the augmented reality environment

3. Performance Testing:

Performance testing assesses the application's responsiveness, scalability, and resource usage under different loads and scenarios. Key performance testing modules for the AR travel application may include:

- Load testing to evaluate the application's performance under expected user loads
- Stress testing to determine the system's stability and performance limits under heavy user loads
- Network testing to assess the application's performance over varying network conditions (e.g., 3G, 4G, Wi-Fi)
- Battery consumption testing for mobile devices during AR usage

4. Compatibility Testing:

Compatibility testing ensures that the application functions correctly across different devices, operating systems, and browsers. Modules for compatibility testing may include:

- Testing the application on various mobile devices (Android, iOS) with different screen sizes and hardware capabilities
- Verifying compatibility with different versions of operating systems (Android, iOS) and their associated APIs
- Testing the application's compatibility with different web browsers (if applicable)

5. Security Testing:

Security testing is essential to identify vulnerabilities and ensure the protection of user data. Modules for security testing may include:

- Authentication and authorization testing to verify secure user login and access controls
- Data privacy and encryption testing to ensure sensitive user information is protected
- Testing against common security vulnerabilities (e.g., SQL injection, cross-site scripting)

Testing Modules:

To ensure effective testing, the following modules can be established:

- Test case development: Creating detailed test cases covering all the application's functionalities and scenarios.
- Test environment setup: Preparing a dedicated test environment that mimics the production environment.
- Test data creation: Generating relevant and diverse test data to cover various scenarios.
- Test execution: Running test cases, recording results, and identifying any failures or discrepancies.
- Defect reporting and management: Logging and tracking identified issues, prioritizing them, and ensuring timely resolution.
- Regression testing: Conducting regression testing to ensure that existing functionality remains unaffected after introducing new features or fixing defects.
- Usability testing: Engaging real users to provide feedback on the application's usability, intuitiveness, and overall user experience.

By incorporating these testing analysis and modules into the development process, the augmented reality travel application can undergo thorough testing, leading to a stable, reliable, and user-friendly product.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Results

The Augmented Reality (AR) Travel Application has undergone thorough development, testing, and deployment to provide users with an immersive and enhanced travel experience. In this section, we present the results obtained from the application's implementation and discuss the implications and potential improvements.

1. User Experience:

The AR Travel Application has successfully provided users with a unique and engaging travel experience. The integration of augmented reality features has allowed users to explore destinations with virtual overlays, providing real-time information, historical context, and interactive elements. The user interface is intuitive, ensuring ease of navigation and seamless interaction with AR components. User feedback and surveys indicate high levels of satisfaction with the application's usability and visual appeal.

2. Geolocation and Navigation:

The application's geolocation services and navigation functionality have proven to be effective in guiding users to their desired destinations. Users can rely on accurate location tracking, interactive maps, and augmented reality markers to navigate unfamiliar areas and discover nearby points of interest. Real-time route guidance and turn-by-turn directions have significantly improved users' travel experiences, reducing the likelihood of getting lost and enhancing overall trip efficiency.

3. Booking and Reservation Management:

The AR Travel Application's integrated booking and reservation management system have simplified the process of planning and organizing travel arrangements. Users can seamlessly book flights, accommodations, tours, and other travel services within the application. The system effectively communicates with external APIs and databases to retrieve up-to-date information on availability, pricing, and booking confirmation. User feedback suggests that this feature has saved time and provided convenience, streamlining the overall travel planning process.

4. Augmented Reality Features:

The application's augmented reality features have been a key highlight, offering users a novel and immersive way to explore and learn about destinations. The AR overlays, including virtual tour guides, historical facts, and 3D visualizations, have added depth and interactivity to the travel experience. Users have reported heightened engagement, increased knowledge retention, and a sense of excitement while using the AR features. This integration has successfully bridged the gap between the digital and physical travel realms.

4.2 Discussion

While the results of the AR Travel Application have been generally positive, there are areas for further discussion and improvement:

1. Device Compatibility and Performance:

The application's performance and compatibility across a wide range of mobile devices and operating systems require ongoing evaluation and optimization. Ensuring smooth operation and optimal performance across various hardware configurations and software versions is crucial to provide a consistent user experience. Regular updates and compatibility testing can address any issues that arise due to hardware limitations or software updates.

2. Content Expansion and Localization:

Expanding the application's content library and incorporating more destinations, landmarks, and points of interest will enhance its utility and attractiveness to a broader user base. Additionally, localizing the content to cater to different languages and cultural contexts will increase the application's global appeal, enabling users worldwide to benefit from its features.

3. User-generated Content and Social Features:

Introducing user-generated content, such as travel reviews, photos, and recommendations, can foster a sense of community within the application. Enabling users to share their travel experiences and engage with others through social features can further enhance the application's value proposition and encourage user retention.

4. Continuous User Feedback and Iterative Updates:

Collecting ongoing user feedback, monitoring usage patterns, and analyzing user behavior will provide valuable insights for future updates and enhancements. By continuously iterating and improving the application based on user feedback, the development team can address pain points, introduce new features, and stay ahead of user expectations.

The results obtained from the implementation of the Augmented Reality Travel Application demonstrate its effectiveness in providing an immersive and enriched travel experience. The integration of augmented reality, geolocation services, and booking functionality has created a user-friendly and engaging platform for users to explore destinations, plan

CHAPTER 4
CONCLUSION

In conclusion, the Augmented Reality (AR) Travel Application has successfully revolutionized the way users engage with travel experiences. Through the seamless integration of augmented reality, geolocation services, and comprehensive booking functionalities, the application has provided users with an immersive and enhanced travel journey.

The application's user experience has been widely praised, with users expressing high levels of satisfaction regarding its intuitive interface, visually appealing design, and seamless navigation. The incorporation of augmented reality features has allowed users to explore destinations in a unique and interactive manner, with virtual overlays providing real-time information, historical context, and engaging visualizations.

Geolocation and navigation functionalities have proven to be valuable assets, guiding users to their destinations efficiently and reducing the likelihood of getting lost. Real-time route guidance, interactive maps, and turn-by-turn directions have significantly improved the travel experience, enhancing convenience and ensuring optimal trip efficiency.

The integrated booking and reservation management system has streamlined the travel planning process, allowing users to effortlessly book flights, accommodations, tours, and other services within the application. By effectively communicating with external APIs and databases, the application provides users with up-to-date information on availability, pricing, and seamless booking confirmation.

Moreover, the augmented reality features of the application have provided users with an entirely new dimension of exploration. The integration of virtual tour guides, historical facts, and 3D visualizations has captivated users, fostering engagement, knowledge retention, and an enhanced sense of excitement throughout their travel experiences.

While the application has achieved significant success, there are areas for further improvement. Continuously assessing device compatibility and optimizing performance across different mobile devices and operating systems will ensure a consistent user experience. Expanding the content library to include a wider range of destinations, localized information, and user-generated content will increase the application's appeal and cater to a diverse user base. Additionally, collecting ongoing user feedback and leveraging data analytics will enable the development team to identify areas for enhancement, introduce new features, and maintain a competitive edge in the market.

Overall, the Augmented Reality Travel Application has proven to be a game-changer in the travel industry. By combining technology, convenience, and immersive experiences, it has enriched the way users engage with travel, unlocking new possibilities and creating memorable journeys. With ongoing improvements and iterations based on user feedback and market trends, the application is poised to continue revolutionizing the travel landscape, inspiring users to explore the world in exciting and innovative ways.

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