ErmitARa: AN ANDROID-BASED AUGMENTED REALITY MOBILE APPLICATION FOR GUIDED HERITAGE WALKS AND INFORMATIVE 3D DISPLAY OF HISTORICAL AND LOCAL TOURIST ATTRACTIONS

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The thesis hereto entitled:

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ABSTRACT

The study developed the "ErmitARa: An Android-Based Augmented Reality Mobile Application for Guided Heritage Walks and Informative 3D Display for Historical and Local Tourist Attractions" that aimed to expand the reach of technology to local tourism by the implementation of augmented reality. The main objective of the application is to boost tourism in the Ermita district of Manila through the following features (a) Present augmented information and three-dimensional images, such as logos or other relevant visuals; (b) Integrate Outlining Augmented Reality (AR) for the navigation process; and (c) Integrate the connection of the following components: social media API links of the places for user sharing and reviews, website for user information, and coordinates for user guidance and navigation to the desired locations. The application facilitates users in acquiring knowledge about numerous tourist spots situated within the district, along with the historical significance associated with these landmarks. Additionally, this application serves as an extracurricular activity for students, providing them with an opportunity to delve into the rich history of Ermita while fostering camaraderie with their peers during exploration of the district. The application possesses the potential to promote history in diverse ways, thereby enhancing the overall tourist experience. The system was developed utilizing Unity 3D, Blender, Mapbox API, Google Maps, Google Earth, and Unity AR+GPS Location assets v3.6.0. This study assessed the application through a survey conducted involving 48 respondents, comprising 28 students, 13 Manila residents, 4 Tourists in Ermita, 2 IT professionals, and 1 Tourism Sector Professional. Based on the results of the evaluation, the developed system gained a grand weighted mean of **3.44** described as **Highly Acceptable**. The results suggest that the application exhibits functional suitability, usability, portability, and performance efficiency.

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THE PROBLEM AND ITS SETTING

Introduction

The tourism industry is a significant contributor to the economic development of many countries worldwide. In 2019, the World Travel and Tourism Council (WTTC) reported that the industry contributed 10.4% to the global GDP, supported 319 million jobs, and generated significant revenue for governments, accounting for 10.5% of total global exports and USD 8.8 trillion in total GDP. The WTTC report emphasized the importance of tourism in creating jobs and promoting economic growth, particularly in developing countries where tourism can play a crucial role in poverty reduction. The tourism industry also has social and cultural benefits, promoting cross-cultural understanding and preserving heritage sites. The report suggests that sustainable tourism practices and technological innovations can help further develop the industry. Overall, the tourism industry is a critical component of the global economy with potential for further growth and sustainable development ("Travel & tourism: economic impact 2019 world", 2019).

Tourism plays an important role in various industries as one of the many contributors to aspects such as employment, investments, capital, and the growth of countries. In the Philippines, it is important to prioritize the development of national tourism as it is an influential and coherent industry. Its impact on the development of society is significant, and it offers powerful peripheral benefits. Additionally, it has a significant impact on cultural development and life support systems ("Tourism Investment Portfolio", n.d). In 2018, the tourism industry was a significant contributor to

the economic growth of the Philippines. As mentioned in the study of Regmi and Fujii (2019) study, it accounted for about 12.7% of the country's GDP, providing employment opportunities and generating revenue for the government. The government has invested in infrastructure and marketing initiatives to promote the country's rich cultural heritage, beaches, and natural wonders, making it an attractive tourist destination. Furthermore, the study suggests that the tourism industry has the potential for further development through the introduction of new tourism products, such as medical tourism and ecotourism. Therefore, it is imperative to continue efforts to promote and develop the tourism industry for the country's economic progress.

The tourism industry has undergone a significant transformation due to technological advancements, which provide various opportunities to promote destinations and enhance the overall tourist experience. Technology such as mobile devices, augmented reality, virtual reality, and social media platforms are widely used to promote tourism. For instance, augmented reality and virtual reality offer immersive experiences that enable tourists to have a more interactive and engaging way of experiencing destinations and attractions with additional information. Social media platforms such as Instagram, Facebook, and Twitter have become critical tools for destination marketing as users share their travel experiences with their followers, creating a buzz around a particular destination.

The tourism industry has witnessed a significant technological shift in recent years, with advancements like virtual reality, artificial intelligence, and mobile applications transforming the way travelers plan and experience their trips. Janta et al. (2020) explained that virtual reality technology allows travelers to preview destinations

and attractions, while artificial intelligence provides personalized recommendations and chatbots for customer service. Mobile applications offer real-time information and customized suggestions to travelers, enabling businesses to enhance customer engagement and loyalty. In addition, technology can promote sustainable practices by reducing paper waste through digital ticketing and monitoring tourist flows to avoid overcrowding. Despite the benefits, challenges like privacy concerns and the need for adequate infrastructure remain significant hurdles in adopting and implementing new technologies. Overall, the integration of technology in tourism has immense potential in improving the travel experience and promoting sustainability.

Guo et al. (2020) conducted a study on the increasing popularity of location-based services (LBS) in the tourism industry. The study suggested that LBS can provide personalized recommendations based on user preferences and current location, enhancing the travel experience for tourists. LBS can assist travelers in finding nearby attractions, restaurants, and accommodations, as well as provide real-time information on transportation schedules and traffic conditions. LBS also offers opportunities for businesses to improve customer engagement and loyalty through tailored recommendations and promotions. Although LBS can assist in crisis management and emergency response, challenges such as privacy concerns and data security remain significant barriers to adoption in the tourism industry it presents great potential for enhancing the travel experience and providing new opportunities for businesses in the tourism industry.

According to Wang et al. (2018), the use of augmented reality technology positively impacts the consumer's purchase intention, creating an increase in the

perceived usefulness, enjoyment, and risk reduction of tourism products and services. Moreover, mobile apps and location-based services can enhance the tourist experience and create new business opportunities for tourism stakeholders, leading to tourism growth. Therefore, technology plays a significant role in driving the growth of tourism and expanding the reach of destinations to a broader audience. The study of Buhalis and Foerste (2018) discussed the advancements in technology which have significantly improved the convenience and accessibility of travel and tourism. Tourists can now utilize mobile devices, such as smartphones and tablets, to book accommodations, plan activities, and navigate unfamiliar destinations effortlessly, resulting in a more seamless travel experience. Self-service kiosks, electronic ticketing, and digital signage are among other technological innovations that have made travel more convenient for tourists, not only enhancing the travel experience but also allowing businesses to improve customer service and operational efficiency. In summary, technology has played a critical role in making travel and tourism more accessible and convenient for people globally.

Background of the Study

According to Penny (2020), there are plenty of ways to promote tourism marketing, from simple brochures to online marketing through websites, digital publications, emails, and other platforms that can be used to market the tourism industry. However, these methods are still not enough to establish a strong marketing presence. Innovations and upgrades to marketing strategies are necessary to achieve this goal. Lohmann and Tussyadiah (2020) investigated the impact of technology on the tourism industry in their article titled "The Impact of Technology on Tourism". They explored the

ways in which technology has revolutionized the planning, booking, and experience of trips for travelers. The authors emphasized the importance of mobile technology, social media, and virtual reality in enhancing the overall travel experience. In addition, the article examined the challenges and opportunities related to technology in tourism, including privacy concerns and the need for personalized experiences. Ultimately, the authors highlighted the significance of embracing technology to remain competitive in the tourism industry.

Tiwari (2019) highlighted the significance of promotion in the tourism industry, emphasizing its crucial role in attracting tourists and generating revenue. To promote tourism, various methods, such as advertising, public relations, and direct marketing, can be employed. The lack of promotion can lead to a decline in tourist arrivals, negatively impacting the local economy. Therefore, effective promotion strategies are necessary to ensure the growth and sustainability of the tourism industry.

Vesnin (2020) discussed the increasing use of smartphones by individuals, citing their portability and accessibility. The article explored the use of Augmented Reality (AR) technology to enhance promotions with entertainment in the tourism industry. AR technology allows for the superimposition of 3D graphics and other visible objects onto the physical environment, creating an additional layer to our surroundings. The author highlighted the potential of AR technology in tourism, as it can provide tourists with an interactive and immersive experience, thus enhancing the overall travel experience. The travel industry has increasingly adopted augmented reality (AR) technology, which involves integrating computer-generated input to enhance aspects of the physical world for users. AR is gaining popularity in the industry due to its ability to encourage tourists

to visit local attractions, including landmarks, museums, and businesses. In recent years, there has been a growing interest in the potential of Augmented Reality (AR) in the tourism industry, leading to an increasing body of research. The travel and tourism industry has recognized the significant potential of AR technology, following in the footsteps of other industries that have embraced this emerging technology ("Interaction Design Foundation", n.d.) AR can transform the travel experience by providing an interactive and immersive experience for tourists, allowing them to engage with destinations and attractions in new and exciting ways, as well as providing valuable information. Additionally, AR technology offers opportunities for tourism businesses to promote local attractions and services through interactive and engaging content, as well as generating new revenue streams such as virtual tours or selling AR-enabled merchandise (Liang & Elliot, 2021).

Augmented Reality (AR) tourism mobile applications are increasingly popular in the Philippines for promoting tourism. These applications use AR technology to overlay digital content, such as images, videos, and text, onto real-world environments, providing tourists with an immersive and interactive experience. The main objective of this application is to create a tourism guide with augmented reality to promote tourism in the district of Ermita, which is the cultural and financial district of Manila, Philippines, and one of the most significant districts in the city of Manila, known for its parks, museums, malls, educational, health, and political institutions. Ermita is also a popular tourist destination in Manila, with easy access through public transit that goes to and from the area. Visitors can take a bus to the edge of Rizal Park and walk around to observe the various attractions ("2022 Ermita Travel Guide | Expedia Philippines", n.d.).

Objectives of the Study

The primary goal of this study is to create an Augmented Reality Android Mobile Application that will serve as a Local Tourism Industry Guide in promoting tourism in the Ermita District of Manila. The application is intended to offer a more engaging and interactive experience to travelers and has the potential to attract more tourists and increase revenue in the district. Specifically, it aims to:

1. Design a mobile application named "ErmitARa" with the following features:
    a. Provide educational information about the district.
    b. Display augmented 3D objects, such as relevant logos or images.
    c. Implement augmented pop-up information pertaining to the location.
    d. Integrate Outlining Augmented Reality (AR) for the navigation process.
    e. Integrate the connection Social Media API links of the sites for user sharing and reviews.
    f. Integrate the connection of website for user information.
    g. Integrate the connection of links that will direct to google maps for user guidance and navigation to the desired locations.
    h. Provide list of emergency services information around the district of Ermita.
    i. Gallery of compiled photos of the attractions in Ermita.
2. Develop the local tourism innovation mobile application using augmented reality with the following tools:
    a. ARCore Software Development Kit of Google Play services v4.2.7
    b. ARFoundation v4.2.7

c. Blender v3.3.1
d. Unity v2021.3.16f1 // 3.13f1
e. Unity AR+GPS Location assets v3.6.0
f. Node.js v18.10.0
g. Java Development Kit v17.05.0
h. Gradle v7.6
i. Google Maps Services
j. Google Earth
k. Mapbox API for Unity SDK
l. Android v7.0 or newer for google play, v8.1 (API 27) for android device emulators.

3. Test and improve the system based on the functional suitability and usability of system functionalities.
4. Evaluate the level of acceptability of the application using ISO 20510 criteria for software quality.

Scope and Limitations of the Study

ErmitARa is a mobile application for Android that uses Augmented Reality to improve the tourism experience in the Ermita district. The application has two important features: AR Heritage Walk and Explore AR. AR Heritage Walk allows users to participate in a guided walking tour to visit selected historical sites. For the feature to function effectively, the walking tour must start and finish at the specified locations indicated within the application. For Explore AR, users can scan their camera at any of

the 10 specified AR Hotspots such as Manila City Hall, Metropolitan Theater, National Library, National Museum Fine of Arts, Rizal Monument, Manila Ocean Park, Philippine General Hospital, Manila Baywalk, The Manila Hotel, and Archdiocesan Shrine of Nuestra Señora De Guia, to see augmented reality objects with information about those locations. It is necessary to be physically present at the site to view the AR objects. Blender 3D design software was used for designing these objects.

The application is intended to operate only on flat surfaces known as ground planes. The application's Augmented Reality capabilities are limited to Android devices that have ARCore services, commonly known as Google Play Services for AR, installed. For best performance, these devices should also include supported Depth Sensors and OpenGL ES.

Moreover, the mobile application includes an attraction gallery in Ermita, allowing users to browse through images of different tourist attractions. Emergency Hotline buttons for the City of Manila were also included, which, when clicked, will directly open the user's phone dialer for emergency situations.

To evaluate the level of acceptability of the system ISO 20510 criteria was used for software quality. A total of 48 respondents tested the features and functions of ErmitARa mobile application and they gave feedback through a survey provided.

Chapter 2

CONCEPTUAL FRAMEWORK

This chapter presents a review of literature and related studies on the area of concern of the study.

Review of Related Literature

The following literatures provide the basis in the development of ErmitARa: Local Tourism Industry Innovation Using Augmented Reality Mobile Application.

Tourism

Tourism is one of the primary contributors to the improvement of the economic sector, employments, businesses in the Philippines. PSA (2019) discussed that tourism continued to be a significant contributor to the Philippine economy, accounting for 12.7% of the country's Gross Domestic Product (GDP). In terms of employment, the tourism industry generated 5.7 million jobs or 13.5% of total employment in the country. The report also showed that tourism receipts reached PHP 2.4 trillion, or approximately USD 47.9 billion, in 2019, indicating the importance of tourism in the Philippines as a source of foreign exchange and a key driver of economic growth.

Tourism is a complex industry made up of many different businesses, the common theme being that they provide products and services to tourists/visitors. According to the United Nations World Tourism Organization (UNWTO), tourism entails the movement of people to countries or places outside their usual environment for personal or business purposes. There are three (3) basic forms of tourism: domestic tourism, inbound tourism, and outbound tourism (“Introduction to tourism”, n.d.).

Many say that the tourist business is the largest in the world, but determining its true value is difficult. Tourism's favorable economic consequences are not always as large as predicted. Tourism has unintended and frequently unanticipated negative economic consequences. The tourist industry accounts for 5% of global GDP and employs 6-7% of the workforce. In terms of global exports, international tourism ranks fourth (after fuels, chemicals, and automotive items). Tourism accounts for 30% of all commercial service exports worldwide. This expansion can be attributed to a variety of factors, including technological advancements and increases in disposable income. According to United Nations World Tourism Organization since 1960's the Asia and the Pacific Region always received the highest international tourist arrival by exceeding 1.2 billion in the year 2016 trailing is the Middle East Region with 900 million. ("Economic Impacts of Tourism", 2022) (See Fig 1 below)

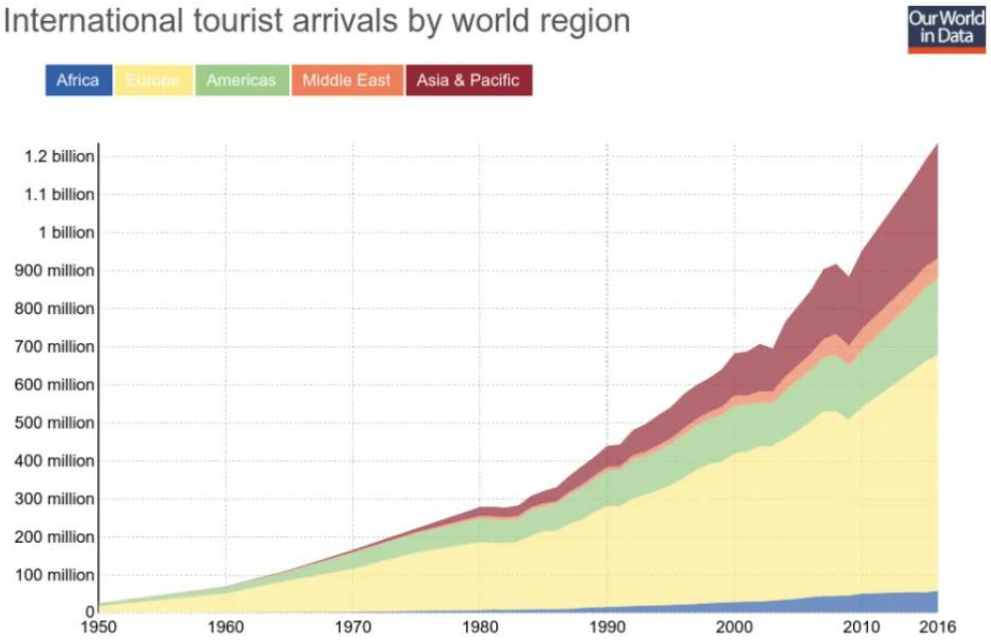


Figure 1. Data of International Tourist Arrival by World Region

Source: *United Nations World Tourism Organization*

According to the report of UNWTO in 2021, international tourist arrivals decreased by 74% in 2020 compared to the previous year, while domestic tourism also suffered significant losses. The report also highlights the challenges faced by the tourism industry during the pandemic, such as travel restrictions, border closures, and the reluctance of tourists to travel due to health and safety concerns. During the early stages of the COVID-19 pandemic, the global tourism industry faced a "sudden and rapid fall" in international tourist arrivals worldwide, with a 22% decrease in February 2020. The UNWTO projected a decline of 20-30% in international tourist arrivals for the year, highlighting the impact of travel restrictions, border closures, and flight cancellations on the tourism industry, resulting in job losses and business closures. The UNWTO called for international cooperation and support for the tourism industry to mitigate the negative impact of the pandemic ("UNWTO, Tourism and COVID-19: UNWTO Briefing Note #1", 2020). In an article published by Das (2022), during the pre-pandemic era, international visitor numbers and revenue both decreased by 82% and 78% in Southeast Asia between 2019 and 2020. The tourism industry, pertaining to many of these nations, was responsible for approximately one-third of all job losses. Many tourists came from China, but their numbers declined by almost 90% during the pandemic years. Therefore, the region has expanded its tourism industry to include specialized industries that draw tourists with higher spending levels and boost local economies. As the COVID-19 happened in 2020, the tourism sector in the Philippines was greatly affected (Caynila et al., 2022). The offices, schools, airports, hotels were used to provide more COVID-19 facilities as well as the restrictions on gatherings to prevent the spread of the virus. The

World Health Organization estimated around 100 to 120 million jobs that are related to travel and services were put at risk (Cabrera et al., 2020).

In the Philippines domestic tourism recorded a surge, tallying 37,279,282 trips in 2021, a 38.16% growth compared to the 26,982,233 trips in 2020. Tourism contributed 11.1% to total employment in the Philippines. The country recorded a total of 163,879 visitors from January to December 2021, a decline of 88.95% from 2020 arrivals of 1,482,535. With 39,326 arrivals, the United States led the country's top visitor markets, followed by Japan (15,024 arrivals) and China (9,674 arrivals). Visitor spending or tourist receipts generated in 2021 recorded an estimated PhP 8.49 billion, a decrease of 89.67% from the visitor receipts of PhP 82.24 billion recorded in the same period of the previous year. The average age of tourists that come to the Philippines is 39 years old, the majority of whom are male travelers, registering at about 59.25% (“DOT”, 2022).

For local tourism, the number increased in 2021. The top three (3) destinations were the National Capital Region, CALABARZON, and Central Luzon with a total of 5,833,028 amid the COVID-19. The campaign “It’s More Fun with You” in the recovery stage of the Philippines helped a lot. With proper protocol and guidelines, and the help of tourism offices, this campaign was successfully standardized (Koumelis, 2022).

The lack of promotion in the tourism sector in the Philippines is still prominent. Budget is one of the biggest problems in the tourism department. Even brochures and information centers are still lacking. Tourists typically are at a loss for what to do, where to go, and what to see. These could affect the media on different platforms since it has played a big role in the growth of the number of tourists (“What are the problems facing tourism industry in the Philippines?”, 2019).

The advances of technology benefit the tourism industry particularly it allows people to see the physical and beauty of the environment, which Augmented Reality can build up. As modern tourists are now fond of using their smartphones when they travel, implementation of Augmented Reality Applications is not a problem anymore. This might assist with advertising because their newly developed Augmented Reality application allows travelers to precisely augment images with a 3D model and information on the actual sites and tourist attractions. For example, the user or tourist may position the camera to a particular location such as church, hotel, school, or any significant place. Immediately, the application will provide detailed information, historical events, near landmarks, and so on. This way could enhance the entire trip and allows tourist to digest and enjoy the information on the go (“How Augmented Reality is Revolutionising the Travel Industry”, n.d.).

Smart Tourism

The rapid growth of smart tourism technology creates new potential for tourism development. Smart technology is being utilized by more tourist places to attract more tourists. Smart tourism is the game changer of today's tourism industry in an era of newly developed technologies. It investigates potential improvements to improve the visitor experience by making it unique to them in a creative way. It is used for promotion and marketing efforts by some businesses and tourist destinations (Chen-Kuo Pai, 2020).

According to Um and Chung (2019), public service segment connections in smart cities increased by 113% between 2015 and 2018. The cultural and tourism industry has grown to be the second largest, accounting for 18.5% of all smart city services. Cities that employ smart tourism are termed "smart tourism cities" by definition. Smart tourism is

also being utilized in several Korean towns as a tactic to revitalize their tourism economies. An article published by Agunias (2021) provided a review of smart tourism in the Philippines, discussing its potential for sustainable development, the applications of smart tourism, and the challenges and opportunities in its implementation. It concluded that the adoption of smart tourism can enhance the competitiveness of the Philippine tourism industry and promote sustainable tourism practices.

ICT in Tourism

ICT is a vital component of smart tourism, acting as both a carrier and a manifestation. Smart tourism technologies encompass not just smart tourism but also smart travel. gadgets, as well as social networks, cloud computing, big data, IoT, and artificial intelligence (AI), virtual reality (VR), augmented reality (AR), mixed reality, near-field communication (NFC), and radio-frequency identification (RFID), which are associated with tourism activities, are becoming Smart Tourism Technologies (STTs) that have grown in popularity in the context of tourism in recent years (Um & Chung, 2019).

Nowadays tourists choose wearable and portable electronics due to advancements in ICT and mobility with practicability. As discussed by Kirova (2018), smartphones are seen as a significant technology capable of influencing visitor behavior. The distinctness of the tourist experience from regular life or job activities emphasizes cellphones' unique significance in the tourism business. This blending of leisure and workspaces and times is known as "fragmented time" and "digital flexibility". In a study conducted by Abel (2019) discussed the importance of information and communication technology (ICT) in tourism development in the Philippines. It examined the role of ICT in promoting sustainable tourism practices and enhancing the competitiveness of the tourism industry

highlighting the various applications of ICT in tourism, including the use of social media, mobile applications, and other digital platforms. The study concluded that the effective utilization of ICT can improve the quality of tourism services, enhance the tourism experience, and contribute to the sustainable development of the Philippine tourism industry.

Local-based services: Travel and Tourism

The development of location-based mobile applications can provide various services such as real-time navigation, restaurant recommendations, and local event notifications, thereby enhancing the tourist experience. These apps can also promote community-based tourism and encourage tourists to engage in local activities and experiences. The article emphasized the importance of using technology to provide more personalized and authentic experiences for travelers, as well as to support local businesses and communities. Furthermore, location-based apps can aid in sustainable tourism development by providing tourists with information on eco-friendly options and encouraging responsible tourism behavior. Overall, the article highlighted the potential benefits of location-based services for both tourists and local communities in the tourism industry ("Location-based apps: undoubted benefits for your business?", 2021). An article by Hammad et al. (2018) reviewed the use of location-based mobile applications (LBAs) in the tourism industry. It discussed the benefits of LBAs in enhancing tourist experience by providing customized and personalized information, improving navigation and wayfinding, facilitating communication with locals and fellow travelers, and promoting local businesses and attractions. The study also highlighted the challenges and concerns related to the use of LBAs in tourism, such as privacy and security issues,

technology limitations, and the digital divide. The study concluded that LBAs have the potential to revolutionize the tourism industry by creating a more engaging, interactive, and memorable experience for travelers.

Historical Sites

Historical sites are essential in preserving and presenting a community's unique cultural identity, which contributes to the development of tourism. By highlighting the historical significance of these sites, local governments and tourism boards can attract visitors interested in learning more about the local history, culture, and traditions. These visitors often stay longer and spend more money, as they are more likely to engage in activities that educate them about the local community's past. In fact, a 2003 survey conducted by the Travel Industry Association found that travelers who include a heritage activity in their itinerary spend more money on their travels. Additionally, heritage tourism can make vacations more memorable for travelers who value learning something new about history, tradition, art, and culture. Therefore, promoting and preserving historical sites can significantly impact the local economy and enhance the cultural richness of a community (Del Rosario, 2020) .

Nuryanti (2016) discussed the role of historical and cultural attractions in tourism development, using Yogyakarta in Indonesia as a case study highlighting the importance of historical and cultural sites as a major tourist attraction and discusses how these sites can contribute to the economic and social development of a destination. The article also explored the challenges and opportunities associated with managing historical and cultural attractions in tourism, including issues of sustainability and cultural heritage preservation. Overall, the article emphasized the importance of recognizing and valuing

the cultural and historical significance of tourism sites to promote sustainable tourism development. Historical sites have a significant role in a country's cultural and national identity. These sites provide tangible proof of the past and are essential in comprehending a nation's history, growth, and heritage. As stated by Kalay and Kvan (2021), historical sites are a crucial aspect of a country's tourism industry, attracting both domestic and international tourists who are interested in exploring the country's cultural heritage. Furthermore, these sites contribute to the development of the local economy by creating job opportunities and generating revenue for the country. The preservation and promotion of historical sites are crucial in maintaining a country's cultural identity, promoting national pride and unity, and contributing to the sustainable development of the tourism industry.

Process for being a historical site

It is the State's responsibility to deepen understanding of every Filipino by promoting, and popularizing the Philippine culture, protect the country's history, both national and local, and the historical treasures The NHCP's mission is to strengthen people's nationalism, love of country, respect for the heroes, and pride in the people's achievements. A criterion for identifying historic sites include those associated with important historical events, heroes and illustrious Filipinos is being set by the commission. As said the property must also bear strong foreign historical or period influences such as Chinese, Arabic, Spanish, Mexican, American, or Japanese. Historic sites and structures in the Philippines are to be classified according to the recognition conferred by the National Historical Commission (NHCP). Sites and structures being proposed for NHCP recognition must possess demonstrable historical

significance. They must also be at least 50 years old and 70% authentic ("GUIDELINES ON THE IDENTIFICATION, CLASSIFICATION, AND RECOGNITION", 2011).

Conservation of historical sites based on NHCP Guidelines

The National Historical Commission and the National Museum have been granted the right to designate historical and cultural sites, monuments, and landmarks as heritage zones. Sec 4. of PD 260; Sec 12 Art. IV of RA 10066: "The National Historical Commission of the Philippines and the National Museum, in consultation with the commission and Housing and Land Use Board or other concerned agencies, shall designate a heritage zone to protect the historical and cultural integrity of a geographical area." This stated law applies to the guidelines for conservation and development of historical center/zones (Conservation of Heritage Zones). Legaspi (2017) provided an overview of the role of the National Historical Commission of the Philippines (NHCP) in the conservation of cultural heritage, including historical sites. The NHCP guidelines and standards were discussed for the conservation and restoration of historical sites, as well as their efforts to promote public awareness and education on cultural heritage preservation. The chapter also included case studies of NHCP conservation projects in the Philippines.

Innovations using technology in historical sites

There are currently eight (8) technological innovations that have become standard for heritage sites. The first innovation is projection mapping, which allows virtual content to be projected onto existing surfaces such as walls, ceilings, floors, and objects. This technique provides an immersive experience that can be viewed up close or from afar and highlights existing features in historical buildings. The second innovation is Binaural technology, which adds an immersive layer to audio. Binaural audio mimics the effect of

immersive sound when played back, creating a feeling of being part of the exhibit for museum visitors. Another innovation discussed is the use of "Digital twins" to preserve and replicate delicate objects. Photogrammetry is a process that creates a virtual model that exists in 3D space, allowing visitors to interact with objects without physically touching them. These technological innovations have helped heritage sites grow their tourism by using different technological and marketing strategies (“8 tech innovations becoming standard in museums and heritage sites”, 2022). Mazzei and Rizzo (2021) mentioned that the utilization of emerging technologies has become increasingly essential in the preservation and promotion of cultural heritage. The study recommended incorporating digital innovations like virtual and augmented reality, 3D scanning and printing, and interactive exhibits to enhance the visitor's experience and provide a more immersive understanding of historical sites.

District of Ermita

Ermita is a historic district in Manila, Philippines, known for its rich history and numerous attractions. According to Sangoyo (2022), Ermita was once a posh neighborhood that served as the residence of Manila's upper class. However, during the Second World War, the area was heavily bombed, resulting in the destruction of many of its magnificent houses and leaving the district in ruins. Despite the damage caused by the war, Ermita managed to recover and transform into a thriving business area that is now home to numerous commercial establishments, including banks, shopping centers, and hotels.

Diocesan Shrine of Nuestra Senora de Guia (Ermita Church)

The Diocesan Shrine of Nuestra Senora de Guia is a significant cultural and religious monument in the Philippines, tracing back to the early Spanish colonial era where it served as a small chapel. It has since undergone renovations and expansions and has become a renowned center for Catholic worship in Manila. Visitors come from all over the world to seek blessings, offer prayers, and witness the shrine's beautiful architecture, intricate carvings, and stunning artwork. The Diocesan Shrine of Nuestra Senora de Guia represents the long and complex history of the Philippines, where Spanish and Filipino cultures intersect, and Catholicism has deep roots in the country. As a center for Catholic worship and cultural heritage, it remains a vital symbol of inspiration, comfort, and spiritual renewal for many Filipinos, playing a crucial role in the country's religious and cultural landscape (Manila, 2020).

Rizal Monument

Rizal Park is a historic urban park located in Manila's Ermita area, near Roxas Boulevard and covering an area of 58 hectares or 580,000 square meters. It is one of the largest urban parks in Asia and is located adjacent to Intramuros, the old walled city. The Rizal Monument, a towering 13-meter structure built to honor the national hero of the Philippines, Dr. Jose Protacio Rizal, is the park's most recognizable feature. The Knights of Rizal, ceremonial sentinels, and soldiers in full uniform, regularly guard the monument and its surroundings. The park was formerly called Bagumbayan, the site where Dr. Jose P. Rizal was executed by a Spanish firing squad on December 30, 1896, an event that sparked the Philippine Revolution against Spanish rule. The Rizal Monument was constructed in 1901, during the American colonial period in the Philippines, through the

help of Philippine Assembly Act No. 243, and it is a major landmark in Philippine history (Jervis, 2022).

Manila City Hall

Manila City Hall is a significant government building in the heart of Manila, Philippines that was constructed during the American colonial period in 1939. Designed by architect Antonio Toledo, it is an Art Deco-style building featuring a clock tower and central dome. Since its establishment, the building has become an iconic landmark and a testament to the city's rich history and architecture. Manila City Hall has played a crucial role in the city's political and social development, serving as a military headquarters during World War II and as the headquarters of the Philippine government until 1976. Today, it serves as the official office of the Mayor of Manila and the city council and houses several government departments while still drawing tourists who come to admire its architecture and learn about its historical significance (“Inquirer.net.”, 2021).

National Library of the Philippines

Established during the American colonial period in 1901, the National Library of the Philippines (NLP) was created with the aim of promoting literacy and education among Filipinos. Over the years, the NLP has broadened its collection to encompass rare and precious materials, becoming a valuable resource for scholars and researchers. The NLP serves as an important custodian of the Philippines' cultural heritage, preserving and granting access to written and printed materials for future generations. Through its services and programs, the NLP has played a vital role in advancing reading, research, and education among Filipinos, making it an indispensable institution in the country's progress and development (“About NLP: History”, 2021).

National Museum of Fine Arts

The National Museum of Fine Arts in the Philippines has a long history, having been founded in 1926 as the National Gallery of Art during the American colonial period. Since then, it has been renamed and has grown into an institution with a vast collection of Philippine art and artifacts that span from pre-colonial times to the contemporary era. These collections include paintings, sculptures, and other visual arts that represent the development of Philippine art through different periods and styles. As a guardian of the nation's artistic heritage, the museum helps to preserve and promote the diverse artistic traditions of the Philippines and provides opportunities for visitors and artists to learn about them. Additionally, the museum plays a significant role in the country's cultural and educational progress by advancing research, education, and public awareness about Philippine art and culture (“National Museum of Fine Arts”, 2021).

Metropolitan Theater Manila

The Metropolitan Theater Manila, completed in 1931, is a highly significant cultural landmark in the Philippines due to its rich history and cultural value. Its design was attributed to the celebrated Filipino architect, Juan Arellano, and it was utilized as a platform for a variety of cultural performances that showcased the country's artistic and cultural heritage. It served as a center for promoting Philippine arts and culture and was considered a reflection of the country's architectural legacy. Despite undergoing several renovations throughout its existence, it eventually fell into disrepair and was shuttered in the 1990s. At present, attempts are underway to restore the theater and safeguard its cultural and historical worth for forthcoming generations. The Metropolitan Theater Manila is a testimony to the Philippines' rich cultural heritage and its contribution to

promoting artistic and cultural expressions in the country (“National Commission for Culture and the Arts”, 2023).

Manila Ocean Park

Manila Ocean Park, which opened in 2008, is an oceanarium situated in Manila, Philippines, that showcases various marine life from 277 species and over 14,000 sea creatures. The park's primary attraction is the Oceanarium, a 25-meter-long underwater tunnel that provides visitors with an up-close view of various marine creatures. Visitors can also explore other attractions, including the Trails to Antarctica, Birds of Prey Kingdom, and Sharks and Rays Dry Encounter, as well as experience a unique fish pedicure at the Fish Spa. The park is significant for its efforts to promote marine life conservation and education in the Philippines. Its exhibits and programs aim to raise awareness about the importance of marine biodiversity and the challenges confronting the ocean and its inhabitants. Additionally, the park provides a unique educational experience for students and other visitors to learn about different marine species and their habitats. Moreover, Manila Ocean Park contributes to the country's tourism industry by attracting domestic and international visitors. Families, school groups, and tourists interested in learning about the Philippines' marine biodiversity and conservation initiatives frequently visit the park (“Manila Ocean Park”, 2020).

Philippine General Hospital

Established in 1907 as the University Hospital, the Philippine General Hospital (PGH) in Manila is the largest government-owned hospital in the Philippines. It provides affordable and high-quality medical services to millions of Filipinos, especially those who cannot afford private medical care. The PGH also functions as a teaching hospital

for the University of the Philippines Manila College of Medicine, where future healthcare professionals gain hands-on experience and training. The hospital is also a center for research and innovation in healthcare, contributing to the development of new medical technologies and treatments in the country ("Philippine General Hospital", 2021).

Manila Baywalk

According to Farheen (2020), the Manila Baywalk is a popular tourist destination in Manila because of its diverse offerings and unique experiential aspects. The act of taking a leisurely stroll along the Baywalk while witnessing the magnificent sunset is widely considered as a mesmerizing experience, drawing attention from both locals and tourists. The Baywalk stretches for about two (2) kilometers along the Manila Bay shoreline, beginning at the American Embassy and ending at the Cultural Center of the Philippines. This advantageous location puts it close to several prominent landmarks, allowing tourists and residents an easy access.

The Manila Hotel

The Manila Hotel is a renowned five-star hotel situated in the center of Manila, Philippines. It was constructed in 1909 to accommodate American tourists and businessmen and has since played a vital role in Philippine history, hosting essential social and political events and entertaining international dignitaries. The hotel has become an iconic symbol of Manila's cultural heritage, delivering luxurious facilities and services to both domestic and foreign guests and highlighting the country's tourism industry's hospitality and distinction (Manila Hotel, n.d).

Artificial Intelligence

Artificial Intelligence (AI) refers to a collection of technologies that enable machines to imitate human cognitive processes, including learning, reasoning, and decision-making. In the past few years, the importance of AI has grown due to its potential to transform various industries, such as healthcare, finance, and manufacturing, among others. According to a study by Gandomi and Haider (2020), AI plays a vital role in tackling complicated issues and making improved decisions through the utilization of data-driven insights. The report emphasized that AI is particularly valuable in fields such as predictive analytics, natural language processing, and image and speech recognition. Additionally, AI is considered an effective tool to increase efficiency, cut costs, and improve overall performance. The significance of AI is expected to grow with the surge of available data, and it has the potential to transform numerous aspects of daily life.

Artificial Intelligence (AI) has been a rapidly growing field in recent years, with numerous applications across various industries. One of the key areas of AI is computer vision, which is the ability of machines to interpret and understand visual information from the world around them. According to a study by Shi et al. (2020), computer vision has been used in numerous fields, including healthcare, transportation, and robotics, among others. In healthcare, computer vision has been used for medical imaging and diagnosis, allowing for faster and more accurate detection of diseases. In transportation, computer vision has been used for self-driving cars and traffic management systems, improving safety and efficiency. In robotics, computer vision has been used for object recognition and tracking, enabling robots to perform complex tasks. The potential

applications of computer vision in various fields are vast, and its continued development is expected to revolutionize many industries in the coming years.

One of the emerging applications of AI in augmented reality (AR) is in marker-less location-based AR, which allows virtual objects to be placed and interacted with in the real-world environment without the need for markers or predefined patterns. According to a study by Zhu et al. (2020), AI plays a critical role in enabling marker-less AR by providing accurate and robust object recognition and tracking in real-time. The study highlighted the use of deep learning algorithms for object recognition and localization, which can analyze and interpret visual data from a user's camera to identify objects and their precise location. AI also enables accurate mapping of the user's physical environment, allowing virtual objects to be placed and interacted with in a realistic manner. The implementation of AI in marker-less location-based AR has the potential to revolutionize many industries, from gaming and entertainment to education and training, by providing a more immersive and engaging user experience.

Markerless Augmented Reality (MAR) has gained popularity as it allows digital content to be overlaid onto the real world without the use of markers or specific patterns. AI is crucial for MAR as it can improve object recognition and tracking accuracy and robustness. AI-based approaches, such as deep learning, have been used to enhance MAR by enabling real-time object detection, recognition, and tracking. These techniques have been used in various applications, including indoor navigation, gaming, and marketing. The integration of AI with MAR is expected to enhance the user experience and enable new use cases in various domains (Zhu, He, & Wei, “Marker-Less Location-Based Augmented Reality Using Artificial Intelligence”, 2020).

Computer Vision

Computer vision is a subfield of artificial intelligence that empowers machines to interpret and analyze visual information derived from the surrounding environment. It entails the development of algorithms and methodologies that enable computers to comprehend images and videos by extracting useful insights from them. Augmented reality (AR) technology, which overlays digital content onto the user's perception of the real world, relies heavily on computer vision. To execute AR, computer vision systems utilize a blend of image processing techniques and machine learning algorithms to recognize and follow the user's environment, including the orientation and position of objects in the scene. As a result, virtual objects can be added and adjusted within the user's view in a way that blends seamlessly with the physical world. In recent years, advancements in computer vision and machine learning have led to significant improvements in the accuracy and speed of AR systems, rendering them more practical and useful in various areas, including education, gaming, and industrial training.

Computer vision technology has undergone significant improvements in recent years, leading to substantial progress in its accuracy and efficiency, particularly in augmented reality (AR). The effectiveness of AR applications heavily relies on computer vision's ability to recognize and comprehend real-world objects and integrate digital content into the user's perception of the physical world. Today, computer vision systems utilize advanced image processing techniques and machine learning algorithms to identify and monitor the user's surroundings and accurately position virtual objects within it. These advancements have resulted in a considerable improvement in the speed and

precision of AR systems, making them more practical and valuable in various fields, including education, gaming, and industrial training (Smith M. , 2021).

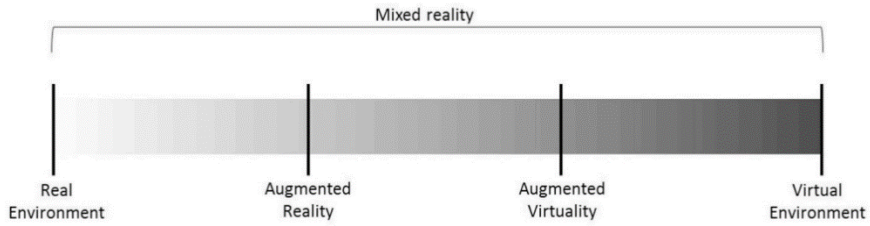
Computer Vision Algorithms in Location Base Applications

According to Chen et al. (2020), computer vision algorithms play a crucial role in improving location-based applications by enabling precise and dependable localization. These algorithms utilize visual data captured by cameras or sensors to detect and recognize landmarks, objects, or features in the surrounding environment. By extracting valuable information from the visual input, computer vision algorithms can accurately determine the user's exact location or track their movement in real-time. These data are then used to provide location-based services and experiences, such as navigation, augmented reality overlays, and personalized recommendations based on the user's specific location. To overcome challenges like occlusions, varying lighting conditions, and complex scenes, computer vision algorithms employ techniques like feature extraction, image matching, and pose estimation. By harnessing the capabilities of computer vision in location-based applications, users can benefit from improved accuracy, enhanced user experiences, and a wide array of context-aware services.

Augmented Reality

The reality-virtuality continuum (RVC) is a framework proposed by Milgram and Kishino in 1994 to define the relationship between the physical and virtual world. The RVC consists of a continuum ranging from the physical environment on one end to fully immersive virtual environments on the other. The RVC has been widely used in virtual

and augmented reality research and development as a guide for defining and exploring the capabilities of visual display technology. The RVC's supporting taxonomy includes three dimensions: the extent of world knowledge, reproduction fidelity, and the extent of the presence metaphor. The RVC provides a useful tool for understanding the relationship between reality and virtuality and can inform the design and implementation of virtual and augmented reality systems (Soh & Jee, 2021). (See Fig. 2) Virtual continuum is a model that describes the relationship between real-world environments, augmented reality (AR), mixed reality (MR), and virtual reality (VR). It represents a spectrum that ranges from the real environment to a fully virtual environment, with AR and MR occupying the middle ground. According to a study by Chen et al., (2020), AR is considered a bridge between the real and virtual worlds, offering users a more immersive experience that blends digital and physical elements. AR applications can be designed to enhance real-world experiences by overlaying virtual objects on top of physical objects. The virtual continuum provides a framework for understanding how AR fits into the larger context of digital experiences. As AR technology continues to evolve, the boundaries between real and virtual environments will become increasingly blurred, creating new opportunities for innovation and creativity in various fields.



Adopted: Milgram and Kishino (1994)

Figure 2. Reality - Virtual Continuum

Augmented reality (AR) is a technology that involves overlaying 3D modeled items onto real-world situations using a mobile device such as a smartphone. There are four types of AR: marker-based, marker-less, projection-based, and superimposition-based. Marker-based AR involves beginning with a picture that initiates an action when it is recognized by a digital device, while marker-less AR uses location-based information to determine what content the user receives or discovers in a specific area. Projection-based AR projects synthetic light onto physical surfaces to detect user interactions with them, while superimposition-based AR uses object recognition to replace the original image partially or fully with an augmented image ("What Is Augmented Reality – Technology, Examples & History", 2022). Augmented reality (AR) can be enhanced by incorporating location-based mapping tools, as these enable the accurate mapping of the user's physical environment and the placement of virtual objects in a realistic manner. According to a study by Li et al. (2020), location-based mapping tools are essential for achieving a high degree of accuracy and reliability in AR applications. The study highlighted the use of Global Navigation Satellite Systems (GNSS), such as GPS, for outdoor environments, and Wi-Fi and Bluetooth for indoor environments. These tools can be used to track the user's location and movement, as well as provide additional information about their surroundings, such as points of interest or historical landmarks. Location-based mapping tools also enable personalized content to be provided to users based on their location and interests, improving the overall user experience. The integration of location-based mapping tools with AR has the potential to revolutionize many industries, from tourism and marketing to education and training, by providing a more immersive and engaging user experience.

Poetker (2019) stated that as users become more reliant on mobile devices, the use of augmented reality technologies will increase. AR software advancements will be the way ahead since most customers own a smartphone and already carry it with them everywhere, making it a practical medium to introduce AR to almost every consumer.

Adil (2022) provided a systematic review of the current state of augmented reality technology for indoor navigation. It examined the latest trends, applications, and challenges of AR-based indoor navigation systems and identifies potential areas for future research and development. The study highlighted the potential of AR-based indoor navigation systems for improving accessibility and wayfinding in various indoor settings, such as shopping malls, airports, and hospitals.

Augmented Reality in Shopping and Health Sector

According to Hayes (2022), augmented reality (AR) is increasingly being used to improve the shopping experience for consumers. The benefits of augmented reality can also be extended to the healthcare sector, where it can play a larger role. When a user hovers their mobile device over a target image, apps display highly detailed 3D renderings of various body systems. An article from MCCLUSKEY (2022) described the future of AR in shopping which discussed that users may virtually try on a pair of Nike Air Force 1s using Snapchat's augmented reality shopping experience. In the next three years, the social commerce industry is expected to grow three times faster than e-commerce. Social commerce sales in the United States are predicted to more than double, hitting $99 billion by 2025. The current state of research on augmented reality experiences in hospitality and tourism was reviewed, including the use of AR in the shopping sector. It explored the potential of AR to enhance the shopping experience,

including virtual try-on, product visualization, and personalized recommendations (Tussyadiah, 2021).

Augmented Reality in Security

It can also be used for security and authorization like the proposed project of Wazir et al. (2020) that uses AR for user verification, which suggested method of using real-time size and coordinate matching of doodles in an AR environment. The combination of doodle passwords and AR in a 3D world is a potential step toward more current, practical, and gratifying authentication systems. The increasing trend of AR is also implemented in sports because it provides viewers with an exciting experience. It also provides extensive analytics to help coaches and players improve their game (Joshi, 2019).

In the future AR will soon be able to display content on TV, phone, or smart glasses. In stadiums, it is possible to offer an interactive way for every visitor to navigate. 5G will probably help to drive innovations in stadiums and bring immersive experiences to physical places (Examples of Augmented Reality (AR) Experiences in Sports, 2020).

Augmented Reality in Tourism

With the large potential of AR in everyday life revealed, numerous researchers have investigated its use in marketing, education, and tourism. There are two (2) main research streams, namely AR adoption and engineering the design of the system. In the year 2015, Jung employed the concept of perceived quality (i.e., AR content quality, system quality, and personal quality) to examine its influence on AR satisfaction, leading to the intention to recommend a system. It is an essential issue to elucidate AR experiences in the travel industry (Stangl, 2020)**.** According to an article of (“Augmented

reality and tourism: the new travel experience", 2022), the concept of digital or smart tourism arose because of changes in tourist mentality and needs brought about by technological advancements. AR provides an infinite number of choices and activities, ranging from location information to gourmet and cultural itineraries, museums, and transportation information, among other things also discussed is the possibility of creating an AR Tour, AR Tour guide, AR Museum experience nowadays.

Tan et al. (2021) discussed the potential of AR in enhancing the tourism experience in Southeast Asia, particularly in the context of cultural heritage tourism. The study highlighted the benefits of using AR, such as providing a more immersive and interactive experience for tourists and enhancing their understanding and appreciation of cultural heritage sites. The study also identified some of the challenges and limitations of AR in tourism, such as technological limitations and the need for effective storytelling.

Artificial intelligence in Augmented Reality

The relationship between Augmented Reality (AR) and Artificial Intelligence (AI) has been an area of research for decades. While AI has faced processing capability bottlenecks, AR has been challenged by the laws of physics. However, the integration of conversational AI with AR can improve the efficiency of maintenance technicians working on complex machinery. The use of AI can enhance AR's ability to recognize and identify objects in real-time, leading to more accurate and efficient AR experiences. Additionally, AI can be used to create more realistic and interactive virtual objects in AR environments. With further development, the combination of AI and AR has the potential to revolutionize industries such as healthcare, education, and manufacturing ("Artificial Intelligence and Augmented Reality", n.d.).

Computer Vision Algorithms in the Implementation of Location-based Augmented Reality

Computer vision algorithms have made significant advancements in enhancing the capabilities of marker less augmented reality (AR) applications that are based on location. These algorithms utilize visual data captured by cameras or sensors to accurately identify and track the user's surroundings without relying on physical markers. By analyzing the visual input, computer vision algorithms can determine the user's real-time location and orientation, enabling the seamless integration of virtual objects into the real-world environment. Marker less AR, driven by these sophisticated computer vision techniques, delivers a more natural and immersive AR experience by removing the limitations associated with predefined markers. Through techniques like feature detection, image matching, and simultaneous localization and mapping (SLAM), location-based marker less AR applications provide users with interactive and context-aware experiences that seamlessly blend virtual and real elements (Srivastava, 2021).

GPS Localization Algorithm in Augmented Reality

According to Liu et al. (2020), GPS localization algorithms have played a critical role in achieving precise positioning within augmented reality (AR) applications. These algorithms leverage data from the Global Positioning System (GPS) to accurately determine the user's location and orientation. By integrating GPS technology with AR, it becomes possible to align virtual content with the real-world environment accurately. GPS localization algorithms analyze the satellite signals received by the GPS receiver and utilize techniques like trilateration or multiliterate to estimate the user's position. Furthermore, they consider factors such as satellite geometry, signal strength, and

atmospheric conditions to enhance the accuracy of the localization process. The fusion of GPS localization algorithms and AR enables the seamless overlay of virtual objects, annotations, or directions onto the user's view, creating an immersive and context-aware AR experience.

Geofencing Algorithm in Augmented Reality

According to a study conducted by Dey et al. (2020), Geofencing algorithms have a critical role in enhancing location-based augmented reality (AR) applications by augmenting objects. These algorithms play a key role in identifying and monitoring users' physical positions within a designated area, forming the basis for creating a seamless AR experience connected to specific locations. To establish virtual boundaries in desired areas, geofencing algorithms combine global positioning system (GPS) data, wireless networks, and digital maps. Through the utilization of these algorithms, AR applications can accurately determine when users enter or exit a predefined location, which then triggers the display of pertinent augmented objects or content. By overlaying digital elements onto the physical environment, geofencing algorithms enable users to perceive and interact with virtual objects in real-world settings. Their significance lies in enriching the user experience by offering contextually relevant and location-specific information across diverse domains like tourism, navigation, marketing, and gaming.

Geolocation Algorithm in Augmented Reality

In a study of Huang and Yang (2020), Geolocation algorithms play a vital role in facilitating augmented reality (AR) encounters. These algorithms are essential for determining the precise location of a user by utilizing a combination of technologies like the global positioning system (GPS), cellular networks, and Wi-Fi signals. By accurately

identifying a user's geolocation, AR applications can superimpose digital information or virtual objects onto the real-world environment in a way that is relevant to the context. Geolocation algorithms examine the user's coordinates and movement patterns to align AR content with their physical surroundings. This alignment allows for the seamless integration of virtual elements into the real world, thereby enhancing the overall AR experience. Geolocation algorithms are crucial for providing location-based AR features such as navigation, points of interest, and interactive experiences tailored to specific geographic locations.

Visual Odometry in Augmented Reality

Visual odometry plays a crucial role in location-based augmented reality (AR) applications. By leveraging computer vision techniques and algorithms, visual odometry enables precise tracking of the user's position and orientation in real-time, facilitating the seamless integration of virtual content into the physical world. The accurate estimation of camera motion provided by visual odometry algorithms allows AR systems to anchor virtual objects to specific locations and align them with the user's viewpoint, creating a convincing and immersive augmented reality experience. This technology is particularly valuable in outdoor environments where GPS signals may be limited or unreliable. According to a study by Mur-Artal et al. (2020), visual odometry algorithms, such as ORB-SLAM2 and LSD-SLAM, have demonstrated significant advancements in robustness, accuracy, and efficiency, making them suitable for real-time location tracking in AR applications.

Image Augmentation

Image augmentation is a technique used in computer vision and deep learning that involves generating new training data from existing data by applying transformations such as rotation, flipping, zooming, and scaling. The purpose of image augmentation is to increase the amount and diversity of data available for training, which can improve the performance and accuracy of deep learning models. Image augmentation can also help prevent overfitting and improve model generalization. As deep learning models become more complex and data-hungry, the importance of image augmentation in improving model accuracy and performance is likely to continue to grow.

In conclusion, image augmentation is a critical technique in computer vision and deep learning that can significantly improve the accuracy and performance of models. Its ability to generate new training data and increase diversity can help prevent overfitting and improve model generalization. As deep learning continues to be widely used in various applications, the importance of image augmentation in improving model accuracy is expected to continue to increase (Shorten, 2022) (See Fig. 3).

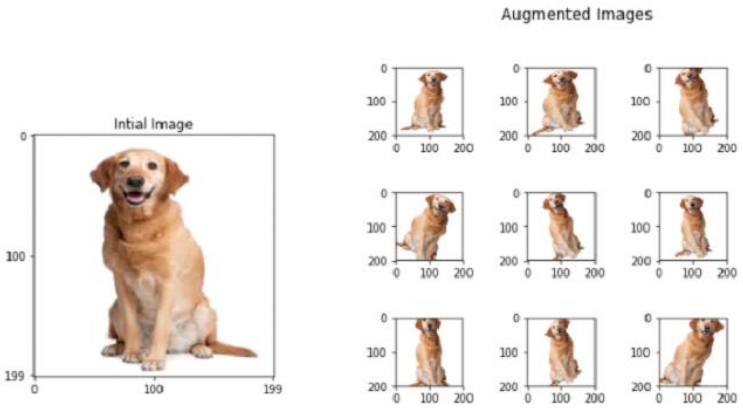


Figure 3. Example of Image Augmentation

ARFoundation

AR Foundation is a cross-platform framework for building augmented reality (AR) applications in Unity. Lee (2021) explained the importance of AR Foundation in creating AR applications that are compatible with both iOS and Android devices. This cross-platform compatibility is essential for developers creating location-based services, including local tourism industry guides using augmented reality mobile applications, as it allows them to reach a wider audience and provide a consistent user experience across different devices. AR Foundation also provides developers with a range of features and tools for creating highly customized and engaging AR experiences, including plane detection and tracking, which enables virtual objects to be placed in the real world. By using AR Foundation, developers can create AR applications that enhance the overall user experience and provide real value to users, making it an essential tool for developers creating location-based services.

ARCore Software Development Kit

As stated in the documentation of ARCore in 2022, Google's framework for creating augmented reality experiences for Android and iOS devices. ARCore allows a phone to perceive its surroundings, interpret the world, and interact with information by utilizing various APIs. Some APIs are available on both platforms, allowing for shared AR experiences. The motion tracking engine in ARCore utilizes the phone's camera to find interesting points, known as features, and monitors how those points move over time. ARCore can also identify flat objects, such as a table or the floor, and estimate the average illumination in the surrounding region. With these capabilities, one may create

totally new AR experiences or add AR elements to existing apps. ARCore is a software development kit (SDK) developed by Google that enables the creation of augmented reality (AR) applications on Android devices. Its importance lies in its ability to provide high-quality AR experiences with advanced features such as motion tracking, environmental understanding, and light estimation, making it a powerful tool for AR projects.

ARCore also offers seamless integration with other popular development platforms such as Unity, making it easier for developers to create AR experiences across multiple platforms. This allows for more efficient development processes, reducing time and cost while improving the quality of AR projects. Furthermore, ARCore provides support for a wide range of Android devices, which means that developers can reach a larger audience with their AR projects. This helps to increase the adoption of AR technology among consumers, which in turn drives the growth of the AR industry.

The global market for AR software and SDKs is expected to reach USD 35.3 billion by 2023, driven by the growing demand for AR in various industries including gaming, entertainment, healthcare, and education. ARCore, being a popular and widely used SDK, is expected to play a significant role in this growth (MarketsandMarkets, 2018).

Mobile Application

A mobile application is a piece of software created expressly for use with a mobile device, like a smartphone or tablet. Back in 2020, a total of 218 billion downloads of mobile applications, top category were communication applications with a percentage of 90.7 number of downloads, with 88.4%, social media applications ranked second on the most downloaded mobile applications. Other types of mobile applications are composed of entertainment (67.2%), navigation (61.8%), music (52.9%), commerce (69.4%), and games (50%) (What Is a Mobile Application?, 2022). (See Fig. 4 below)

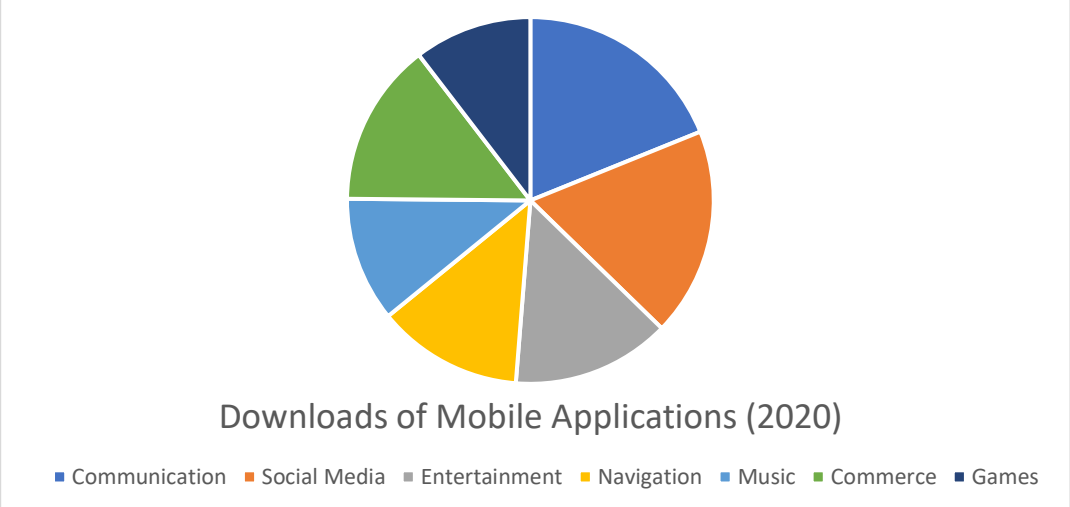


Figure 4. Growth of Downloads of Mobile Applications in 2020

According to Pedamkar (2020), mobile applications have become widely utilized in various sectors, including business and entertainment, due to the significant role played by smartphones in our daily lives. These devices offer a portable and convenient way to access various applications that have transformed the way people use their smartphones. Nowadays, smartphones are considered a necessity rather than a luxury item, with the availability of numerous mobile applications further increasing their usefulness. The

continuous advancement in technology has significantly influenced the use of mobile applications, making it hard to imagine life without them. The primary aim of mobile application development is to create practical and convenient tools that can reshape our perception of various aspects of life. A study of Arshad et al. (2022) presented a thorough analysis of the present state of innovation in mobile applications, covering its description, classifications, and variables that impact its effectiveness. The study concluded that the innovation of mobile applications is a multifaceted and intricate process that includes various actors like developers, users, and organizations. The authors suggested that future research should focus on examining the contribution of emerging technologies, particularly augmented reality, in the innovation of mobile applications, and developing suitable frameworks and models to direct the innovation process.

Augmented Reality Mobile Application

Mobile Augmented Reality (AR) is a technology that allows users to experience augmented reality through their smartphones. The concept of AR was first introduced in 1968 at Harvard University by computer graphics pioneer Ivan Sutherland, who created an AR/VR head-mounted display device. Previously, augmented reality was only used in exhibition rooms and multi-player games. However, with mobile AR, it has become more practical and accessible for everyone to enjoy the benefits of AR technology. By superimposing multiple layers of digital information on top of the physical environment, AR enhances the surroundings with sound, video, and graphics. AR technology has the potential to improve various aspects of life, including education and employment. According to Markets & Markets, the market for mobile AR is predicted to reach $61.39 billion by 2023 (Fourtané, 2020).

In a recent research by Hsu et al. (2021), they conducted a comprehensive examination of mobile applications that implement augmented reality technology, exploring its concepts, features, and prospects. The investigation revealed that AR mobile apps are primarily used in education, entertainment, and marketing, and often involve the use of markers, sensors, and geolocation functionality. The authors identified various prospects and challenges for the future development of AR mobile apps, including enhancing the user experience, enhancing content creation tools, and discovering new types of interaction. In general, the research emphasizes the potential of AR mobile apps to enhance the quality of user experience and create new opportunities for engagement and learning.

Compatibility Testing of Mobile Application

Mobile compatibility testing is a crucial step to ensure that an application functions correctly on various devices and browsers. It aims to confirm that the application performs as intended across different device and browser combinations. Unlike usability testing, which evaluates the application's overall look, feel, and ease of use, compatibility testing focuses on the application's functionality on different devices. The goal of compatibility testing is to improve user experience and promote better app usage metrics. This type of testing is typically conducted prior to app launch to ensure that the app operates smoothly on different devices, operating systems, and browser versions. Testing teams work to create a bug-free and user-friendly mobile application that is compatible with multiple operating systems, including Windows, macOS, and Linux (Ghosh, 2022). In a recent study of Gupta et al. (2022), they highlighted the importance of compatibility testing in mobile application development. They discussed

the various challenges associated with ensuring compatibility across multiple devices, operating systems, and screen sizes. They provided an overview of the different types of compatibility testing, such as functional, non-functional, and performance testing. The study concluded that the compatibility testing is crucial for the success of a mobile application, as it ensures that the app functions properly across a wide range of devices and platforms.

Global Positioning System

A global positioning system or also known as GPS, is a network of satellites and equipment on Earth that uses radio waves. The position of certain GPS receivers may be determined to within one centimeter. There are a total of 24 satellites that have accurate orbit around the Earth. (GPS, n.d.) For the past years, reliable and more precise GPS allowed scientists to monitor and examine how the land moves during convulsions. It has become the forewarning for different disasters (Witze, 2019).

There are two (2) types of GPS in the mobile phone industry namely, Assisted GPS and Simultaneous GPS. Assisted GPS reduces the time it takes for GPS-based positioning systems to start up, this sort of GPS is utilized. In cases where the signal is weak, the A-GPS would help the receiver obtain a lock. The A-GPS needs the assistance server to obtain the lock, therefore for this to function, a network connection in the mobile phone is necessary. Simultaneous GPS is a way to make satellite-based reporting to a network carrier reliable. A cell phone with the S-GPS can simultaneously receive GPS and Voice Data, increasing sensitivity and enabling location-based services from network providers (Bhawani, 2019). The report of Tracko (2018) laid out the benefits and

impact of GPS in Tourism Industry. GPS provides different services such as passable routes, stopover stations, live location, real-time data, and alerts for accidents. In the Philippines, the most widely used GPS receiver is the newer Garmin with wide area augmentation system that has an accuracy ranging from 0-3 meters on average. This network is composed of towers that receive GPS signals and convert a signal by transmitters. ("How accurate is GPS?", n.d).

GPS is a powerful and dependable tool for businesses and organizations in many different industries. Surveyors, scientists, pilots, boat captains, first responders, and workers in mining and agriculture are just some of the people who use GPS daily for work. There are five main uses of GPS: Location for Determining a position. Navigation for Getting from one location to another. Timing for Making it possible to take precise time measurements, Tracking for Monitoring object or personal movement and Mapping for Creating maps of the world ("What is GPS?", 2020).

GPS Process in Mobile Applications

According to Hildenbrand (2020), a phone uses Assisted Global Positioning System. AGPS adds cellular location data to assist geolocation. AGPS does send data out of the phone, but its data that was already being sent when it checks for cell towers in range. There are five (5) main uses of GPS: Determining a position, navigating, mapping, tracking, and time-measuring. One will need an active data plan to use AGPS.

Cell phones contain low-power transmitters that let them communicate with the nearest tower. As one travels, he/she moves from one cell to another, and the base stations monitor the strength of the signal. In remote locations, towers may be so far apart that they cannot provide a consistent signal. Even without a GPS receiver, a cell phone

can provide information about a person's location. A computer can determine the location based on measurements of the signal. These include the user's angle of approach to the cell towers. The length of time it takes the signal to travel to multiple towers (Wilson, n.d.). According to a recent study by Sharma (2022), GPS technology is extensively utilized in mobile apps for navigation, location-based services, and tracking. Nonetheless, GPS localization accuracy can be influenced by several factors like signal reflections, atmospheric conditions, and satellite signal interference. To enhance localization accuracy, the study suggests using advanced GPS technologies like differential GPS and Real-Time Kinematic (RTK) GPS. The study recommended a testing strategy that comprises functional testing, performance testing, and user experience testing to ensure GPS functionality accuracy and usability in mobile applications.

Location-Based Services

A location-based service (LBS) is a software service for mobile device applications that requires information of the mobile device's geographical position. The program gathers geodata, which is data obtained in real time using one or more location tracking technologies.

Pull

Pull type location-based services offer location-based information to users upon their request, providing directions and relevant information about nearby places. Users can control their location privacy and access pull type LBS through devices such as smartphones, tablets, and laptops. The benefits include enhanced user experience, time

and money savings, and improved public safety, with potential benefits expected to increase as technology advances (Zhang & Wang, 2021).

Push

This type of location-based system is based on a trigger or regular intervals with the intervention of significant information based on the location of the user. The main example is Proximity-based marketing. After the program detects that a user is in the vicinity of a given retail establishment, an advertisement or voucher is delivered to that user (Froehlich, 2022).

According to a recent study of Hosseini and Hamidi (2021), push type location-based services automatically provide users with location-based information based on their location or preferences, and offer benefits such as personalized recommendations, alerts, advertising, and public safety warnings. Users can choose to opt-in or opt-out of push type LBS to balance the benefits with privacy concerns. Although push type LBS can improve the user experience and provide convenience, it is essential to consider privacy concerns and give users control over their data and preferences.

Location-based services applications are now becoming complex software to mobile application publishers as this gives advantages and assistance to multiple industries. Its popularity in the IT industry is still growing as of now and by 2024 the expected market will reach $40 billion (“Location-based apps: undoubted benefits for your business?”, 2021). Location-based services (LBS) are crucial in mobile applications as they offer users personalized information based on their location. This information can include nearby businesses, events, and services that can enhance the user experience, save time and money, and improve safety. LBS rely on GPS, Wi-Fi, and cellular

networks to determine the user's location, and mobile apps can use APIs provided by location service providers, such as Google Maps or Apple Maps, to integrate LBS. Various industries, including retail, transportation, tourism, and healthcare, can benefit from LBS to offer personalized promotions, emergency services, and patient tracking (Zhang et al., 2021).

Gradle

Gradle is a widely used open-source build automation tool that simplifies and automates the software build process, reducing errors and saving time. Its use of a Groovy-based DSL allows for customization and supports incremental builds, which only build the parts of a project that have been changed. Gradle is popular in software development, mobile development, and web development due to its flexibility, ease of use, and ability to integrate with various technologies and frameworks. Its importance is likely to continue to grow as the software development industry evolves (Gradle, 2022).

Gradle, according to Gaba, is a build automation tool known for its versatility in building applications. A build automation tool is used to automate application development. The code is compiled, linked, and packaged during the construction process. It is well-known for its ability to create automation in languages such as Java, Scala, Android, C/C++, and Groovy. Over XML, the program supports groovy-based Domain Specific Language. Gradle allows one to develop, test, and distribute applications across several platforms. Gradle builds are used to specify the scope of a project and its tasks. The project's root folder has at least one Gradle build file. As other people prefer working on a different IDE, Gradle provides a variety of it. It is an

excellent tool to use if users want to work on the terminal with the command-line interface (Gaba, 2022).

C# language

C# is a high-level, object-oriented programming language developed by Microsoft for building Windows desktop applications, web applications, and mobile apps for iOS and Android platforms. It has a syntax similar to that of C and C++, which makes it easy to learn for those familiar with these languages. C# provides advanced features like garbage collection and type safety that help to prevent common programming errors. As a widely used language, C# is expected to remain an important part of the software development industry. C# is an important programming language in Unity, a game development engine used for creating video games for various platforms. Its object-oriented nature makes it a suitable language for game development as it allows for easy management of complex game systems. The use of C# in Unity allows for the creation of high-quality games with advanced graphics and gameplay features. C# is integrated with Unity's API, which provides developers with access to various tools and features to build their games and offers features like garbage collection and type safety to prevent common programming errors and improve game stability (“C# Language Overview”, 2021).

Unity Platform

Unity is a cross-platform game development engine that simplifies the creation of high-quality games for various platforms. It provides a range of tools and features, including support for multiple programming languages, to cater to developers with

different skill levels. Unity's user-friendly interface allows developers to focus on game creation rather than writing code. It is widely used in the gaming industry by both indie developers and large game development studios. The popularity of Unity is expected to increase as the gaming industry continues to evolve.

According to Petty (n.d.), both 2D and 3D development is possible in Unity, with 2D physics handled by the popular Box2D engine. With powerful shaders, physics-based materials, post-processing, and high-resolution lighting systems, Unity can deliver impressive graphics across the board. For those willing to pay, Unity offers some extra features and a flexible licensing plan under a tiered subscription model. Unity is a good all-around engine that can handle almost anyone's needs. Creating 2D games in Unity is more painful than using Godot or Gamemaker. Unreal's rendering and lighting systems are more capable than Unity's. Most will not have access to the source code which can make Unity seem like a black box.

Unity AR

Unity AR is the use of the Unity game development engine to create augmented reality (AR) applications. AR overlays digital information onto the physical world, creating interactive and immersive experiences for users. Unity AR allows developers to create AR apps for a wide range of devices, without requiring advanced programming knowledge. The popularity of Unity AR is increasing as more businesses recognize its potential for creating engaging experiences in gaming, education, marketing, and training. As AR technology continues to evolve, the importance of Unity AR is likely to continue to grow. The AR Foundation in Unity is a cross-platform framework that allows

you to create augmented reality experiences once and then build for either Android or iOS devices without making any further changes. The framework is accessible as part of the Unity AR Foundation package. It uses Google's ARCore platform that is used to create augmented reality experiences. ARCore allows the user's phone to perceive its surroundings, interpret the world, and interact with information by utilizing various APIs. Some of the APIs for shared AR experiences are available on both Android and iOS (ARCore, 2022).

Unity Assets

Unity assets refer to digital resources like 3D models, textures, sound effects, and scripts used in developing games and apps in the Unity engine. These assets can be created by developers, downloaded from the Unity Asset Store, or purchased from third-party websites. Unity assets can save time and effort in the game development process and allow developers to focus on creating unique gameplay mechanics. The Unity Asset Store provides a vast library of assets that can be easily integrated into Unity projects, making it an excellent resource for both indie developers and large game development studios. An asset may come from a file created outside of Unity, such as a 3D model, an audio file, an image, or any of the other types of files that Unity supports. The Asset store is sorted into the different types of assets available, which include vehicles, characters, props, vegetation, and animations. Example of Assets are 3D, 2D, Add Ons, Audio, VFX, Templates and Tools ("Unity Assets Store", n.d.).

Prefab Assets

The Prefab Asset serves as a template for creating new Prefab instances in the Scene. Prefabs in Unity are pre-made game objects that can be used multiple times

throughout a project, simplifying game development by allowing for the easy reuse of complex game objects with multiple components and properties. Prefabs can be edited centrally, with changes made to the original automatically applied to all instances of that prefab in the project. The use of prefabs in game development can save time and effort, while also improving consistency and quality. As Unity continues to be a popular game development engine, the importance of prefabs in game development is likely to continue to increase. Prefabs are a type of component that saves fully configured GameObjects in the Project for reuse. These elements may thus be shared between scenes or even projects without needing to be reconfigured. This is particularly beneficial for objects that will be used repeatedly, such as platforms. Prefabs have the significant advantage of being connected copies of the assets that exist in the Project window. This means that any changes made or applied to the original Prefab will be replicated across all instances. This makes it incredibly easy to correct object issues, switch out graphics, and make other style modifications (Prefabs, 2023).

Unity AR+GPS Location Unity Assets

As discussed in the documentation of Unity AR+GPS Location Unity Assets, this package uses Unity and Augmented-Reality, the AR+GPS Location package allows the developer to position 3D objects in real-world geographical areas using GPS coordinates. It works with both the Unity AR Foundation and Vuforia. This package contains the following features that can assemble 3D objects at geographical places determined by latitude, longitude, and altitude called AR Hotspots that are triggered when the user is near a certain area. Can place 3D Text markers on real-world landmarks (example using OpenStreetMap's is included) It gives smooth updates to device location and direction. It

can also be used to move or put items on the map following routes (Catmull-rom splines), Floor shadows in augmented reality and Catmull-rom curves and splines for general use. It works by combining GPS data with AR tracking from the AR Foundation or Vuforia (Fortes, 2020).

Catmull-rom splines importance for route path

Catmull-Rom splines are widely used in computer graphics and animation to create smooth curves and have also found application in generating route paths in location-based services. The implementation of Catmull-Rom splines in AR+GPS assets has gained popularity due to their ability to produce visually appealing and mathematically precise curved paths. In a recent study by Kim et al. (2021), Catmull-Rom splines were used in an AR+GPS asset to create route paths that closely follow the terrain of the real-world environment. The authors emphasized the significance of integrating real-world data such as elevation and terrain information into the Catmull-Rom spline path generation process to improve accuracy. The study concluded that Catmull-Rom splines are a useful and efficient method for generating route paths in location-based services and AR+GPS assets.

Magnetic And GPS Sensors for AR Location based Services

Location-based services for augmented reality (AR) rely on magnetic and GPS sensors, which provide crucial information about device orientation and location. The magnetic sensor, also known as a compass, helps align digital content with the physical environment, while GPS sensors provide location-based information. However, the accuracy of these sensors can be impacted by various factors, such as electromagnetic

interference and atmospheric conditions. A study by Lee et al. (2020) emphasized the importance of optimizing the use of these sensors in AR applications by analyzing environmental factors and calibrating the sensors. The study highlighted the need to develop strategies to mitigate the impact of these limitations and challenges on location-based AR services.

Gyroscope for better performance

In the context of mobile applications, the gyroscope plays an important role in determining the orientation of the device and enabling multi-directional movement. Gyro sensors embedded in smartphones measure the rate of rotation around the device's x, y, and z axes, allowing for seamless transitions between portrait and landscape modes. In gaming applications, the gyroscope enables players to aim and direct movement in multiple directions by sending information to the display driver. Therefore, the gyroscope is an essential component in mobile applications, providing users with a more immersive and interactive experience (“Why is Gyroscope Important for Virtual Reality?”, 2022).

Use of Compass in Location Services

According to Iannarino (2018), in the context of location services, the compass plays a crucial role in providing users with a sense of direction. While GPS technology can provide detailed information on the best route to take, a compass offers a simpler yet essential piece of information: the direction of travel. This information can be particularly useful in situations where GPS signals are weak or unavailable, or when users need to navigate in unfamiliar terrain. Therefore, the compass remains an important tool in

location services, complementing the capabilities of GPS technology and providing users with a more complete navigation experience.

WebMapEditor

The webmaploader is an essential feature in the AR+GPS Unity asset that enables developers to create location-based AR applications using web maps. According to a study by Jain et al. (2021), the webmaploader allows developers to integrate web maps, such as OpenStreetMap, Google Maps, and Bing Maps, into their AR applications. The study also highlighted the benefits of using web maps in location-based AR applications, such as the availability of real-time location data, accurate mapping, and easy integration with existing data sources. The webmaploader feature in AR+GPS Unity asset simplifies the process of integrating web maps into AR applications and offers various customization options, including adjusting the map zoom level and adding custom markers. Additionally, the webmaploader can enhance the user experience in location-based AR applications by providing accurate and up-to-date location information. Overall, the webmaploader in AR+GPS Unity asset is a powerful tool for developers to create engaging and innovative location-based AR applications (Jain et al., 2021).

Mapbox API

Mapbox API is a location data platform that offers developers access to a variety of geospatial data and tools for building custom mapping applications. The platform offers a range of APIs, including mapping, geocoding, routing, and navigation, among others. It is used by developers to build location-based applications for a variety of industries, including transportation, logistics, real estate, and more. Mapbox API provides

developers with the flexibility to customize their mapping applications and integrate them into their existing systems. Mapbox provides a set of APIs for integrating directions into your application. With the Mapbox Directions API, users can generate a route with trip durations, estimated distances, and turn-by-turn directions; with the Mapbox Matrix API, users can retrieve travel times between many points; with the Mapbox Optimization API, users can retrieve duration-optimized trips between points; and with the Mapbox Map Matching API, users can align existing fuzzy routes to the route able network with the release of Mapbox GL and the open source Mapbox Style Specification, a new world of dynamic mapping applications became available, and Mapbox evolved into a company dedicated to developing tools that put these capabilities in the hands of developers ("Getting started: directions", n.d.).

Mapbox SDK for unity

The Mapbox SDK for Unity is a powerful tool that enables developers to create immersive and interactive maps for mobile and desktop applications. By integrating the Mapbox SDK into Unity, developers can access a wide range of features, including real-time location data, custom map styles, and advanced geocoding capabilities. This allows for the creation of highly customized and engaging maps that can be used in a variety of applications, including local tourism industry guides. The Mapbox SDK for Unity provides developers with a flexible and scalable platform for building location-based applications, making it an essential tool for any developer looking to create innovative and engaging maps ("Maps for Unity", n.d.).

Mapbox Navigation API

The Mapbox Navigation API is a powerful tool for developers who want to create navigation applications that provide real-time, turn-by-turn directions to users. Its ability to provide real-time traffic data, voice-guided navigation, and customizable map styles makes it a powerful tool for creating highly customized and engaging navigation experiences that can be used in a variety of applications, including local tourism industry guides (“Navigation maps for people, packages, and vehicles”, n.d.). By providing users with a highly customized and engaging navigation experience, developers can create applications that stand out from the competition and provide real value to users. Therefore, the Mapbox Navigation API is an essential tool for developers who want to create navigation applications that provide a seamless and efficient experience for users.

Mapbox Search Overview API

The Mapbox Search Overview API is an essential tool for developers who want to create location-based applications that provide users with accurate and relevant search results. Its ability to provide geocoding, reverse geocoding, and autocomplete features, as well as access to a wide range of data sources, makes it a powerful tool for creating highly customized and engaging search experiences that can be used in a variety of applications, including local tourism industry guides (“Search API”, n.d.). By providing developers with access to accurate and relevant search results, the Mapbox Search Overview API enables developers to create applications that provide users with a seamless and efficient experience, enhancing the overall user experience and providing real value to users.

Google Maps

According to Zola (2022), Google Maps is a web-based mapping service that provides users with detailed information about geographical regions and sites worldwide. The service offers conventional road maps, as well as aerial and satellite views of various locations, and street views that consist of photographs taken from vehicles. Zola also emphasized the numerous features and benefits of Google Maps, including its ability to provide real-time traffic updates, directions, and location-based recommendations.

Google Earth KML File for routes and distance detection

Google Earth's KML (Keyhole Markup Language) file is a useful tool for creating routes and detecting distances in augmented reality (AR) applications. According to a study by Singh et al. (2020), the KML file format provides a simple and efficient way to create and import geospatial data such as routes, points of interest, and other location-based information into AR applications. This allows developers to create more immersive and interactive AR experiences that are better aligned with the physical environment. The KML file format can also be used for detecting the distance between two points, which is important for location-based AR applications that rely on precise distance measurements for accurate positioning and alignment of digital content. Singh et al. (2020) demonstrated the effectiveness of using KML files for creating routes and detecting distances in a prototype AR application for cultural heritage tourism. The study highlights the potential of KML files as a useful tool for developers to enhance the accuracy and interactivity of location-based AR applications.

The Open Geospatial Consortium, Inc. (OGC) manages the KML worldwide standard. KML is a geographic visualization XML language that includes maps and image annotation. Geographic visualization includes not just displaying graphical data on a globe, but also controlling the user's navigation in terms of where to go and what to look at (KML - Open Geospatial Consortium (ogc.org).

Parsing and Displaying KML in Unity

Parsing KML in Unity involves extracting and interpreting geospatial data encoded in the Keyhole Markup Language (KML) format, allowing developers to import and process geographic elements into Unity applications. This capability enables the creation of interactive experiences leveraging geospatial information, whether it is dynamic maps, geolocation features, or virtual landscapes.

Dijkstra’s Algorithm

Dr. Edsger W. Dijkstra, a brilliant Dutch computer scientist and software engineer, developed and published this algorithm. He explained his new algorithm in a 3-page article titled "A note on two problems in connexion with graphs" published in 1959. Dijkstra's Algorithm begins at the node one provides (the source node) and analyzes the graph to discover the shortest path between that node and all of the other nodes in the network. The method keeps track of the currently known shortest distance between each node and the source node, and it changes these values if a shorter path is discovered. When the algorithm finds the shortest path between the source and another node, it marks that node as "visited" and adds it to the path. The technique is repeated until all of the nodes in the graph are added to the path. As a result, we have a path that connects the

source node to all other nodes by taking the shortest possible path to each node (Navone E. C., “Dijkstra's Shortest Path Algorithm - A Detailed and Visual Introduction”, 2020).

Implementations of Dijkstra’s Algorithm

Algorithm has several real-world use cases in navigation and pathfinding, some of which are as follows:

a. **Digital Mapping Services in Google Maps** use Dijkstra's Algorithm to calculate the shortest distance between two points along a path. Consider India to be a graph, with each city/place represented by a vertigo and the route between two cities/places represented by an edge. The shortest paths between any two cities or locations may be computed using this approach.

b. **Flighting Agenda.** The agent has access to a database that contains information about all airports and flights. Flights have a departure and arrival time in addition to the flight number, origin airport, and destination. The agent is specifically looking for the earliest arrival time for the destination given an original airport and a start time.

c. **Robotic Path** nowadays Drones, and robots are used to deliver packages to a specific location or for a specific task. The drones/robots are loaded with an algorithm module so that when the source and destination is known, the robot/drone moves in the ordered direction by following the shortest path to keep delivering the package in a minimum amount of time (Applications of Dijkstra’s shortest path algorithm, 2022).

Dijkstra’s algorithm importance in location-based services

Dijkstra's Algorithm is a valuable tool for developers creating location-based services, as it allows them to find the shortest path between nodes in a graph. Specifically, the algorithm can find the shortest path from a node (known as the "source node") to all other nodes in the graph, producing a shortest-path tree. This algorithm is widely used in GPS devices to find the shortest path between the current location and the destination and has broad applications in industries that require modeling networks (Navone, 2020). According to a study by Anand et al. (2021), Dijkstra's algorithm is commonly used in location-based services to optimize routing and navigation. The study highlighted the importance of optimizing routing and navigation to provide better user experiences in location-based services. By using Dijkstra's algorithm, location-based services can provide users with the shortest and most efficient route to their destination. The algorithm considers the distance, travel time, and other relevant factors to determine the optimal route. The study also emphasized the need for ongoing research to improve the efficiency and effectiveness of routing and navigation in location-based services. The use of Dijkstra's algorithm is expected to continue to play a crucial role in optimizing location-based services in the future.

Blender 3D

Blender 3D is an open-source software used for creating 3D models, animations, and visual effects that can be used in various media, such as films, games, and animations. With its user-friendly interface and customization options, both beginners and experts can use it effectively. Blender supports a broad range of file formats that facilitate smooth collaboration with other software and tools. Its extensive features and

versatility have made it a preferred choice among 3D artists, animators, and game developers. Given the ever-increasing demand for 3D graphics in various industries, Blender's importance is expected to continue growing in the future (Blender.org, 2023).

Blender has emerged as the most widely used 3D modeling software as of 2021. According to official data from the Blender Foundation, the software was downloaded from the official website 14 million times in 2020, making it significantly more popular than other 3D modeling programs like 3ds Max, Maya, Cinema 4D, and Sketchup. Blender has gained popularity by providing a high-quality free alternative to these more expensive solutions. Among its many capabilities, Blender can be used to create and export 3D models for use in augmented reality mobile applications. Blender is a popular choice for creatives who want to avoid the cost of more expensive alternatives. With Blender, users can work on both animated and static 3D models while setting appropriate parameters that make the model compatible with mobile devices. These parameters include the right polygon count, texture optimization, and specific file formats (“Inglobe Technologies”, 2021).

Java Development Kit

Java Development Kit (JDK) is a necessary toolset for developing software systems using the Java programming language. It comprises a compiler, runtime environment, and libraries that enable developers to create, test, and debug Java applications. JDK is vital to the development of web, mobile, and desktop applications. Its importance in software development cannot be overstated, and it is expected to remain a critical toolset for Java developers in the future. The latest version of JDK is JDK 17, which was released in September 2021, and it comes with several new features. The Java

Development Kit (JDK) is a cross-platformed software development environment that offers a collection of tools and libraries necessary for developing Java-based software applications and applets. It is a core package used in Java, along with the JVM (Java Virtual Machine) and the JRE (Java Runtime Environment). Beginners often get confused with JRE and JDK, if one is only interested in running Java programs on the machine then he/she can easily do it using JRE ("JDK in Java", 2022).

Node.js

Node.js is an open-source server-side platform that allows developers to execute JavaScript code outside of a web browser. It is a lightweight and efficient framework that is ideal for building scalable network applications, particularly web servers, real-time chat applications, and API servers. With its extensive library of modules, Node.js simplifies the development process and allows for easier integration with other systems. As cloud-based applications become more popular, Node.js is becoming increasingly important in software development. Node.js version 16, which was released in April 2021, includes several new features that improve support for ECMAScript modules and the Node.js package ecosystem. The framework is powered by the open-source V8 JavaScript engine, which is also used in browsers such as Google Chrome ("What is Node?", n.d).

Software Product Quality Evaluation

The ISO/IEC 25010 is called the "product quality evaluation system," which was built around the quality model. The quality model specifies which quality attributes will be considered when assessing the properties of a software product. The degree to which a system satisfies the stated and implicit needs of its many stakeholders and, hence, provides value is defined as its quality. The needs of those stakeholders (for example, functionality, performance, security, and maintainability) are precisely what are reflected in the quality model, which divides product quality into characteristics and sub-characteristics (“ISO25000 Standards”, n.d.).

Functional suitability is the degree to which a product or system performs functions that meet defined and implied needs when employed under specified conditions. It is made up of the following sub-features:

- **Functional completeness.** The extent to which the set of functions addresses all of the defined tasks and user goals.
- **Functional correctness.** The extent to which a product or system produces the desired outputs with the needed precision**.**
- **Functional appropriateness.** The degree to which the functions facilitate the accomplishment of specified tasks and objectives.

Performance efficiency represents performance proportion to the quantity of resources used under specified parameters. It is made up of the following sub-features:

- **Time behavior.** The extent to which a product's or system's response and processing times,

- **Resource utilization.** The extent to which a product's or system's amounts and types of resources meet requirements when performing its functions.
- **Capacity.** The extent to which a product's or system's maximum limitations fulfill criteria.

Usability refers to the level to which certain users can utilize a product or system to achieve stated goals with effectiveness, efficiency, and satisfaction in a specific context of use. It is made up of the following sub-features:

- **Operability.** The degree to which a product or system has characteristics that make it simple to use and control.
- **User error protection.** The extent to which a system safeguards users from making errors.
- **User interface aesthetics.** The extent to which a user interface enables appealing and fulfilling interaction.

Portability is the degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another:

- **Installability.** refers to the ease and effectiveness of installing or uninstalling a software system in a specified environment.
- **Replaceability.** refer to the ease of replacing a software component or module without disrupting the overall system's functionality or compatibility.

The acceptability of each component in the current system was assessed using all the ISO 25010 criteria provided (ISO/IEC 25010, n.d.).

Related Studies

Several studies have been conducted to promote tourism using Augmented Reality in different parts of the world.

A recent study in Malaysia developed by Mustapha (2021), presented an application that includes marketing videos of interesting sites and treasures so that travelers may plan their trip before going. Geolocation AR elements allow tourists to rapidly discover sites, while marker features provide information about the locations and treasures. One of its benefits is that the user may move around and observe the virtual environment "stick" to the stone's physical surface. Navigation systems benefit significantly from location-based Augmented Reality. Marker-based AR assists in describing and providing important points based on markers placed at strategic locations throughout specified location which is Terengganu, Malaysia.

A study from Bhatt et al. (2020) suggested that portable mobile application model for improving the use of technology in the travel business has been developed using expanded augmented reality innovation. The tactics' prerequisites, talents, and deficiencies are depicted. This program anticipates giving the client interaction when the object is recognized so that further info may be accessed. The augmented reality technology was implemented using Unity 3D software with Vuforia Engine, and the mobile application was developed using Android application development tools such as Android Studio. The aim of this study is to enhance the domestic and international tourism sectors in the world. Mixing the digital world and the real world gives the user the ability to explore and experience a knowledgeable platform.

Magnusson (2022) developed a prototype of a smartphone application that contains an augmented reality map over Karlskrona City in Sweden and recognizes the user's location. A working GPS tracker on an AR map overlay was used to determine the user's location and assist with navigation in a prototype. On top of the real-world locations of the landmark, two (2) markers were added to the AR map. Once the user clicks on one of these landmark markers, a text window would appear providing information on the landmark. Many testers believed that the prototype developed would assist them during a visit to a new unknown region because of this study. They also felt that if new features were added to the program, they would use it more regularly.

The study of Lee and Chen (2021) examined how augmented reality (AR) affects the experiential value and behavioral intentions of tourists in the tourism industry. The study surveyed tourists who used an AR mobile application during their visit to a cultural attraction in Taiwan, and the results showed that the use of AR technology significantly increased the experiential value of tourists and positively impacted their behavioral intentions to revisit the attraction and recommend it to others. The study concluded that the use of AR technology in tourism can enhance tourists' experiences and promote cultural attractions. As AR technology advances, it is likely to become an increasingly important tool for tourism marketing and promotion.

A study by Chang (2021) evaluated the effectiveness of augmented reality (AR) for tourism marketing. A survey was conducted among tourists who used an AR mobile application during their visit to a cultural attraction in Taiwan, and the results demonstrated that AR technology significantly increased tourists' engagement and satisfaction, which positively influenced their behavioral intentions. The study suggested

that AR can be an effective tool for tourism marketing by enhancing tourists' experiences and promoting cultural attractions. As AR technology continues to advance, it is likely to become an increasingly important tool for tourism promotion.

A study carried out by Yaqoob et al. (2021) named AI-based Mobile Augmented Reality for Smart Tourism explored the implementation of AI techniques in an AR tourism application to enhance the user experience. The app uses computer vision an AI field to identify and provide information about tourist attractions in real-time. The study found that the integration of AI techniques in the AR tourism app improved the overall user experience and satisfaction, as well as increased the user engagement with the app.

Han and J. (2019) investigated the effectiveness of mobile augmented reality (MAR) applications on tourist attractions. The survey results revealed that the use of MAR applications had a positive impact on tourists' perceived value, satisfaction, and behavioral intentions. The authors concluded that MAR can be a valuable tool for enhancing the tourism experience and promoting cultural attractions. A relevant updated reference is the International Symposium on Mixed and Augmented Reality (ISMAR), which provides the latest research and developments in AR and MR technology.

Yoon et al. (2021) proposed a system for personalized tourism guidance that used computer vision and augmented reality to provide users with relevant information based on their preferences. The system utilized deep learning algorithms to analyze images and videos captured by the user's smartphone camera and identify relevant objects and landmarks. Based on this information, the system provided personalized recommendations for nearby points of interest and activities, as well as relevant historical and cultural information. In a real-world tourism setting, the effectiveness of the

proposed approach was evaluated through a user study. Participants who used the computer vision-based AR system reported higher satisfaction levels with personalized recommendations, which led the authors to conclude that the integration of computer vision and AI could improve tourism guidance.

Chen et al. (2020) developed an automatic tourist attraction outlining system that highlights points of interest in real-time using computer vision-based object detection through an AR application. The proposed system utilizes a deep learning-based object detection algorithm to identify and outline tourist attractions, improving the user's navigation experience. Experiments were conducted to evaluate the effectiveness of the system and it was compared with a traditional guidebook approach. The results showed that the computer vision-based AR system provided more accurate and timely outlining of tourist attractions, leading to higher user satisfaction and a more efficient navigation experience. The authors suggested that integrating computer vision and AI in outlining AR tourism applications could improve the user experience and facilitate exploration of unfamiliar environments.

In their study, Cheng et al. (2020) created an AR tourism application that utilizes computer vision and KML data to outline and highlight tourist attractions. The system uses a deep learning algorithm to identify landmarks and display them as AR objects on the user's smartphone. KML files provide additional information such as the attraction's name, description, and location. A user study conducted in a real-world tourism setting showed that the AR application was effective and received positive feedback from participants who found the KML information helpful and informative. The authors

suggest that combining computer vision, AI, and KML data has the potential to enhance the user experience and make exploring unfamiliar environments easier.

Zhang et al. (2021) developed an augmented reality (AR) tourism application that incorporates computer vision and KML data to provide pathfinding and outlining of tourist attractions. The system utilizes a deep learning-based object detection algorithm to identify landmarks and tourist attractions in real-time and recommends a path for users to navigate to their destination. A user study conducted in a real-world tourism setting demonstrated that participants using the AR tourism application reported higher levels of satisfaction with the pathfinding and outlining of tourist attractions and found the additional information provided by the KML files to be helpful and informative. The authors suggested that the integration of computer vision and AI in AR tourism applications, along with the use of KML data, has the potential to improve the user experience and facilitate exploration of unfamiliar environments.

Alonzo (2019) developed an augmented reality (AR) mobile application to enhance the tourist experience in Intramuros, Manila, Philippines. The AR application provides historical and cultural information about the tourist attractions in Intramuros and includes interactive features such as 3D models and audio guides. The authors conducted a survey among tourists who used the AR application during their visit to Intramuros, and the results showed that the AR application significantly enhanced their overall experience and satisfaction. The study concluded that AR technology can be a useful tool for tourism marketing and promotion in the Philippines.

Conceptual Model of the Study

This section discusses the conceptual model of the study composed of tools needed (software and hardware), process of each step, final output, and evaluation of the developed system.

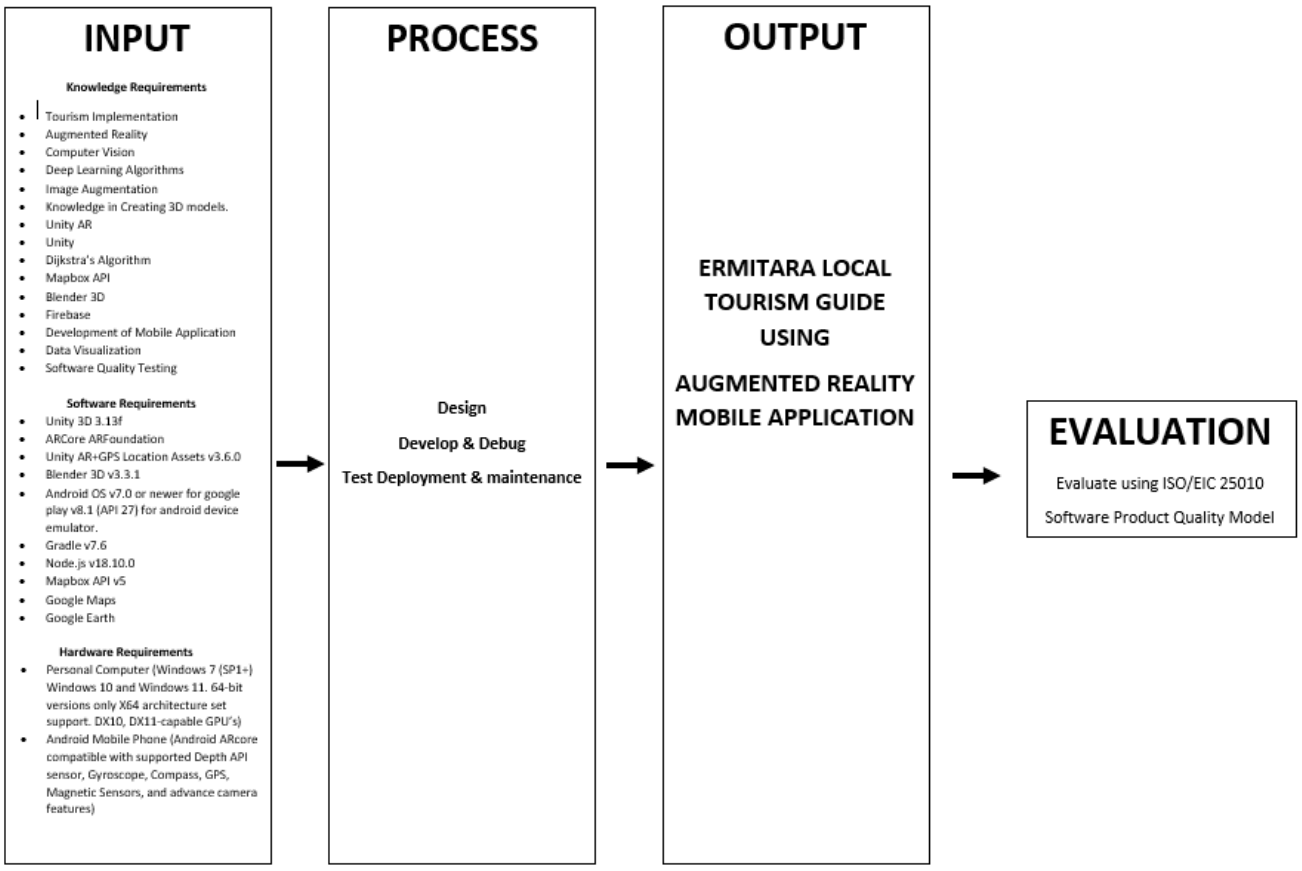


Figure 5. Conceptual Model of the Study

Input

The input section is composed of the requirements of the project, namely: knowledge, software, and hardware. The knowledge requirements are needed to have a brief background on each element of the project such as the implementation of tourism

details, augmented reality, computer vision, filtering of visual odometry and location-based algorithms, 3D models augmentation, using Blender 3D to make 3D models, Unity AR for the main concept for augmentation, Unity as the Platform, Mapbox as the mapping software development tool, Dijkstra algorithm concept to determine the shortest path in two waypoints in google maps for plotting of KML file in Google Earth, develop a mobile application, visualize models in the augmentation. For the software requirements, the main tool for the study is the Unity 3D v3.13f1 which allowed the researchers to develop the augmentation of objects, ARCore and ARFoundation are the packages inside the Unity that are required to install for the project, Unity AR+GPS v3.6.0 is the helping asset for the acquisition of the coordinates and the 3D models used for AR augmentation and Outlining AR. Blender 3D v3.3.1 is the tool for creating 3D models. Gradle for the automation tool to build the application, Node js v18.0.0 for the back end programming, Hardware components are personal computer with minimum requirements (Windows 7 (SP1+), Windows 10 and Windows 11, 64-bit versions only, X64 architecture with SSE2 instruction set support, DX10, DX11, and DX12-capable GPUs) since Unity has minimum system requirements for each operating system, and mobile android phone that supports ARCore package compatibility should be supported with Depth API sensor, Gyroscope, Compass, GPS, Magnetic Sensors, and advance camera features.

Process

The process phase of the study includes the designing, developing, testing, implementation/deployment, and maintenance to finalize the Augmentation and the android mobile application.

Design. In this phase, the flow of the project is being created, which served as a guide for integrating each component. The integration of tourism details in Unity AR is used as the tool for augmenting the objects. User interface and user experience design are also being developed. Diagrams have been created to explain the process and phases of implementing Unity AR as the main tool in the study, as well as discussing the integration of the necessary Software Development Kits.

Develop. During this phase, ideas should be applied and developed through coding. Actual programming took place, utilizing Unity. The researchers employed an Integrated Development Environment (IDE), such as Visual Studio Code, for editing scripts. Learning platforms like GitHub and YouTube were utilized to acquire knowledge on integrating each component. The creation of 3D objects in Blender 3D also occured in this phase. Following the development of individual sections, the Unity project was integrated and connected to the user interface of the mobile application.

Test. In this phase, the project underwent testing and evaluation to assess its feasibility and accuracy. On-site testing was conducted to determine if both AR Objects and Outlining AR can be successfully augmented at the designated locations. Any failed test was subjected to further programming and deployment iterations to ensure accuracy.

Output

The output of the study includes image integration for both AR Objects and Outlining AR. The augmented reality mobile application was subjected to establish its acceptability.

Operational Definition of Terms

The following terminologies are defined for a better understanding the study:

Tourism Mobile Application – A tourist app provides interactive maps, attraction info, navigation aid, augmented reality, and more to enhance the tourist experience.

3D objects – are essentially made up of vertices, which come together to form a mesh and act as the core of the 3D model.

Navigation Assistance - Navigation assistance in the mobile app includes turn-by-turn directions, route guidance, and nearby attraction suggestions based on the user's current location.

Geolocation - Geolocation is the process of determining and tracking the precise geographic location of a person, device, or object.

Wayfinding – is the process of orienting and traveling from place to place.

Points of interest - are a specific location that holds unique or significant interest for various reasons. These locations can include tourist spots, cultural or historical sites, recreational areas, scenic views, or even archaeological landmarks.

Tourisification - Tourisification is the process of transforming an area into a tourist destination, which can have both positive and negative impacts on the local community.

Chapter 3

METHODOLOGY

This chapter is composed of the research methodology of the study with the following sections: project design, project development, operation and testing procedure, and evaluation procedure.

Project Design

The study employed multiple modeling methods to assess the system's scope and guide for project development. This section discusses the project design of the developed system consisting of the Visual Table of Contents (VTOC), Architecture of the Application, and AR process of augmentation flowchart.

The Visual Table of Contents, as shown in Figure 6, provides an overview of the software's various parts. It covers several major components, including District of Ermita, AR Experience, Attractions, and Emergency Hotlines. The District of Ermita module of the software includes useful information and statistics about the district. Users are provided with an Interactive Map, which allows them to select and explore various attractions. This map is essential for visitors since it displays the area and its many places of interest in a clear and easy-to-understand approach. When users select a place on the map, they can access more details about that specific location. The AR Experience module includes three (3) important features designed to increase user engagement and exploration. First, the AR Hotspots feature provides users with a large list of specific areas where they can discover augmented reality objects. Second, the Explore AR button

activates the camera, allowing users to scan their surroundings and unlock AR objects when they are at hotspot locations. This integrates the real world with virtual elements, providing an immersive and captivating experience as users visually explore the AR content within their actual environment. Third, the AR Heritage Walk feature allows users to participate in a guided virtual tour of nearby places and attractions. By selecting the AR Heritage Walk button, users gain access to a comprehensive list of sites through the camera interface. This function facilitates virtual exploration, improving users' knowledge and appreciation of the rich heritage and cultural significance associated with each location.

The app's Attractions module provides users with detailed information about nearby attractions. It includes buttons that represent each attraction, and when a user selects a button, he/she is presented with comprehensive details and a gallery of that location. Finally, the Emergency Hotlines section lists emergency service hotlines located in the vicinity of Ermita.

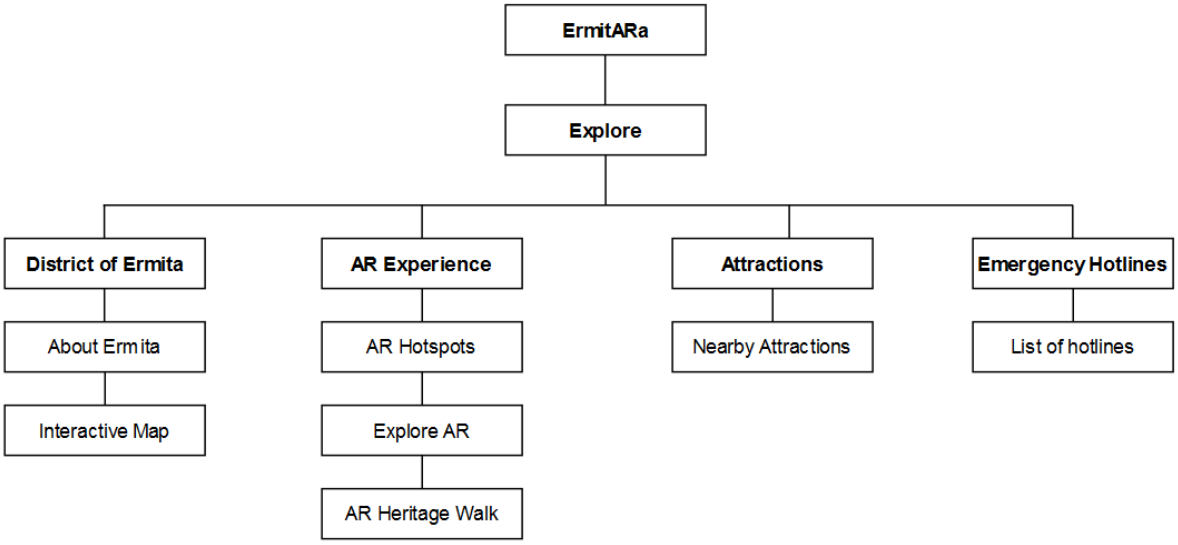


Figure 6. Visual Table of Contents (VTOC) of ErmitARa Mobile Application

The architecture of the application, as depicted in Figure 7, illustrates how the system acquires the necessary information for the Augmentation component within the mobile application. The live video augmentation entails the utilization of the camera, content overlay, tracking, rendering, and display functionalities. The content required for display encompasses Outlining AR and Augmented Object markers.

Regarding the input, it undergoes processing within the AR Framework, specifically Unity ARFoundation. Within this framework, multiple processes occur, including location tracking/recognition, which is filtered by location-based algorithms. Additionally, parsing of KML files and processing of text and 3D objects are filtered by visual odometry algorithms. These algorithms aid in recognizing and tracking objects within the real world, facilitating the overlaying of virtual images onto them.

Once processed by the AR Framework, the mobile device should possess GPS sensors, magnetic sensors, a compass, and a functioning gyroscope to enhance the object augmentation experience. For the output, it ultimately runs through the AR application, if location access is enabled.

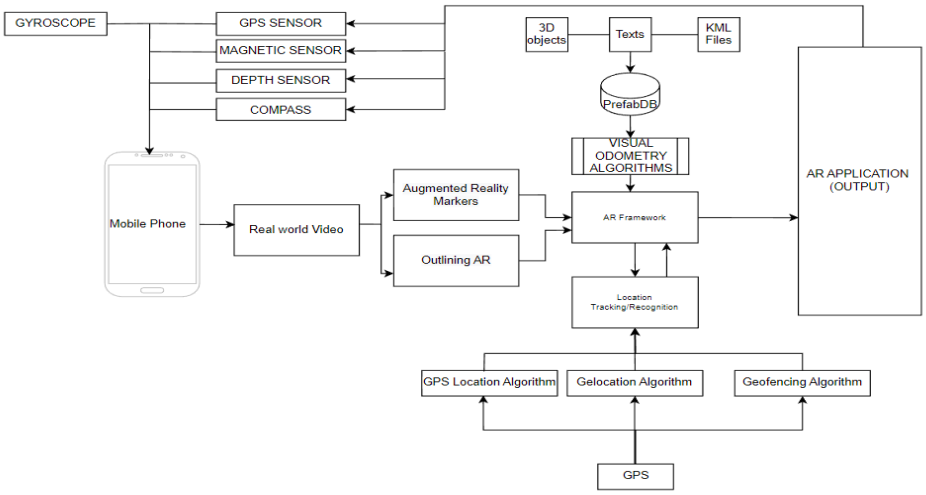


Figure 7. Architecture of the ErmitARa Augmented Reality

The flowchart depicting the process of AR augmentation using GPS data is illustrated in Figure 8.

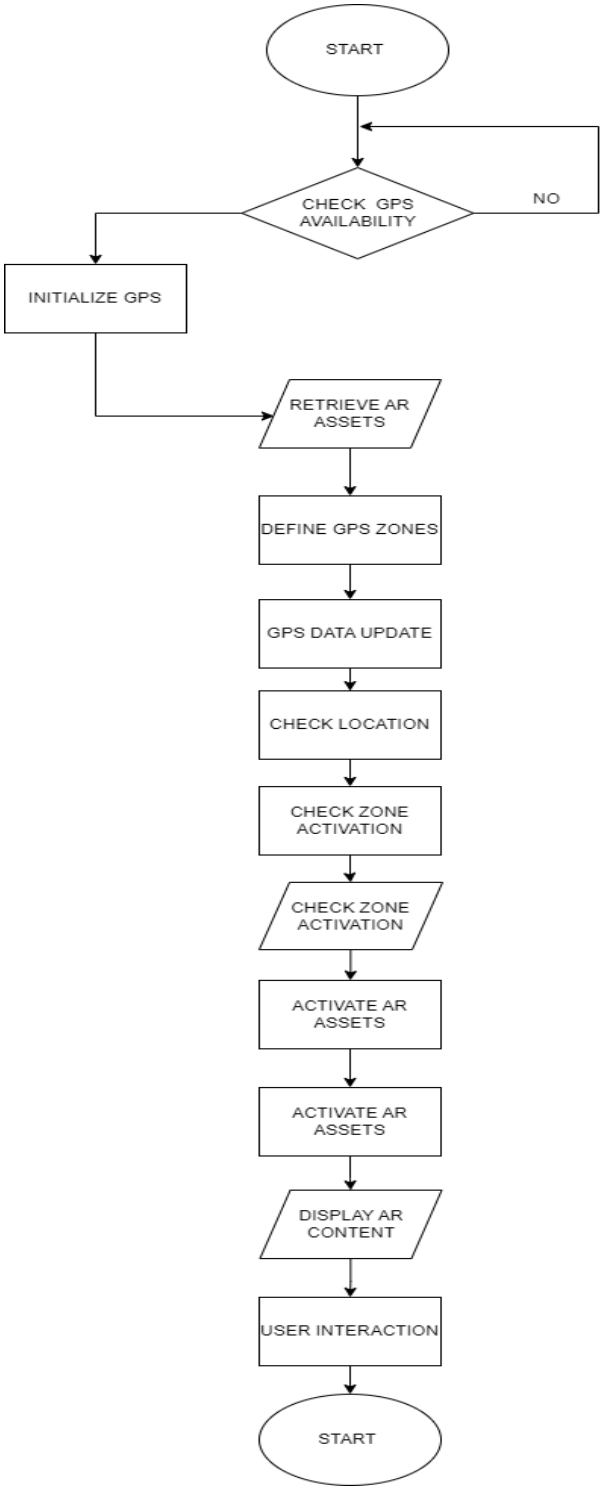


Figure 8. Process of AR augmentation using GPS Data

The process of augmenting augmented reality (AR) using GPS data consists of several sequential steps. Initially, the presence of GPS functionality on the device is verified to ensure its availability. Subsequently, the GPS system is initialized to retrieve the device's current location data. AR assets, including 3D models, images, or animations, are then acquired to be overlaid with the GPS data. Specific geographic zones or coordinates are designated as GPS zones, specifying the areas where AR objects will be positioned or activated. To ensure precise location tracking, the GPS data is continuously updated and monitored. The device's current location is determined by evaluating the GPS data, followed by an assessment to confirm whether it falls within the predetermined GPS zones for AR augmentation. Upon matching the predefined zones, the corresponding AR assets are activated, enriching the user's visual experience. These AR assets are rendered and displayed on the device screen, seamlessly integrated into the real-world environment. User interaction is enabled to facilitate engagement, empowering users to interact with, manipulate, or access supplementary information pertaining to the GPS-based AR objects. Ultimately, the AR+GPS augmentation process concludes, having enhanced the user's perception of reality through AR technology and GPS integration.

Software Design

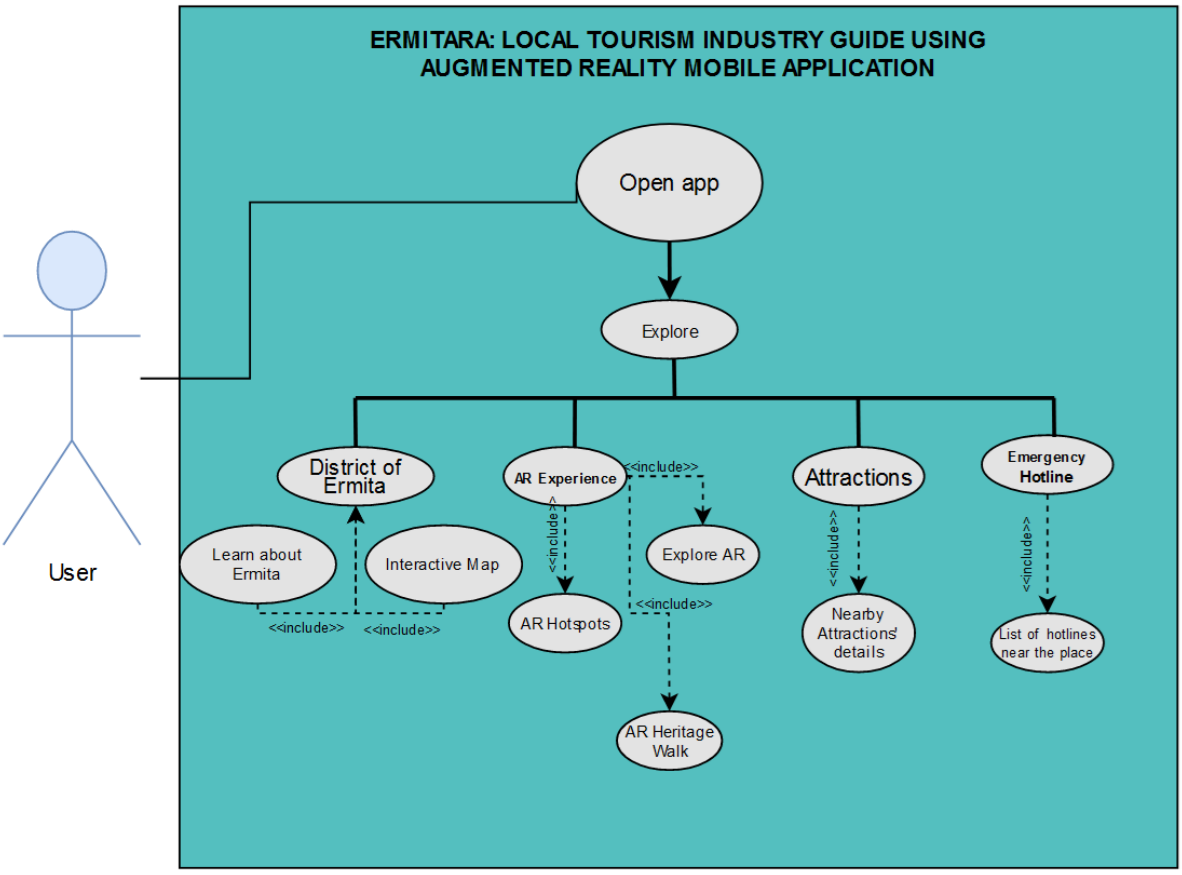


Figure 9. Use Case Diagram of ErmitARa Mobile Application

Based on system software requirements, the following are the features of the Local Tourism Industry guide using Augmented Reality Mobile Application:

- Open the application.
- Select District of Ermita page to access information and statistical data about the district of Ermita and its Interactive Map.
- Select AR Experience to view the list of AR Hotspots or to Explore AR or to try the AR Heritage Walk.

- Select Attractions page to view the list of tourist attractions in Ermita including its information and a gallery.
- Select Emergency Hotline to see a list of hotlines in the City of Manila.

Project Development

This phase discusses the process followed on how the augmented reality mobile application was developed based on the design specifications.

Plotting of Coordinates

This section discusses the plotting of coordinates in the web map editor using the gathered data that have been measured on the exact site or location. This is for the purpose of better image augmentation and to test its functionality if it will be exactly measured when the user points its phone, while the augmentation undergoes. The gathered plotted coordinates will be saved in an XML file format and will be used for data parsing.

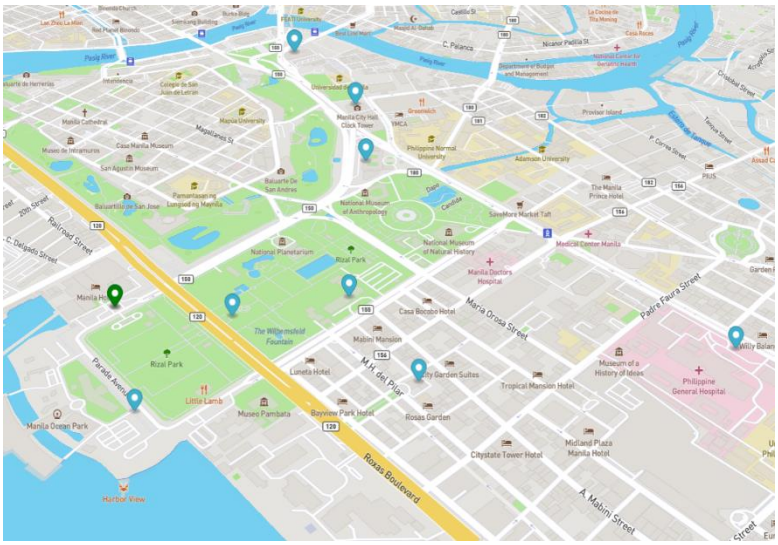


Figure 10. Plotting of Coordinates

Table 1 shows the exact coordinates used in the plotting in the XML file.

Table 1.

Coordinates of the Places

PLACES	LONGITUDE	LATITUDE
1. Ermita Church	120.9798554002769	14.578800223297648
2. Manila City Hall	120.98177585009154	14.588692361417827
3. Metropolitan Theater	120.98057209936464	14.594070162887933,
4. National Library of the Philippines	120.97941631631072	14.581458449287426
5. National Museum of Fine Arts	120.98095196816712	14.58709594045586
6. Rizal Monument	120.97696780311253	14.581768139972297
7. Manila Hotel	120.97416129731901	14.58276800125356
8. Manila Ocean Park	120.97331780287095	14.579797355840482
9. Manila Baywalk	120.97982720810364	14.574756749557142
10. Philippine General Hospital	120.9866222246489	14.578245754718806

Plotting of Routes

This section discusses the plotting of routes in Google based on the given shortest path using Dijkstra's Algorithm. The route will be automatically obtained from Google Maps using the API or a similar service, and the extracted data will be formatted into a KML file structure. This KML file can then be imported into Google Earth. The gathered data, measured on the exact site or location, will be used to enhance image augmentation,

and test the functionality to ensure precise measurements when the user points his/her phone during the augmentation process. The plotted route will be saved in a KML file format and utilized for data parsing (See Fig.11 below).

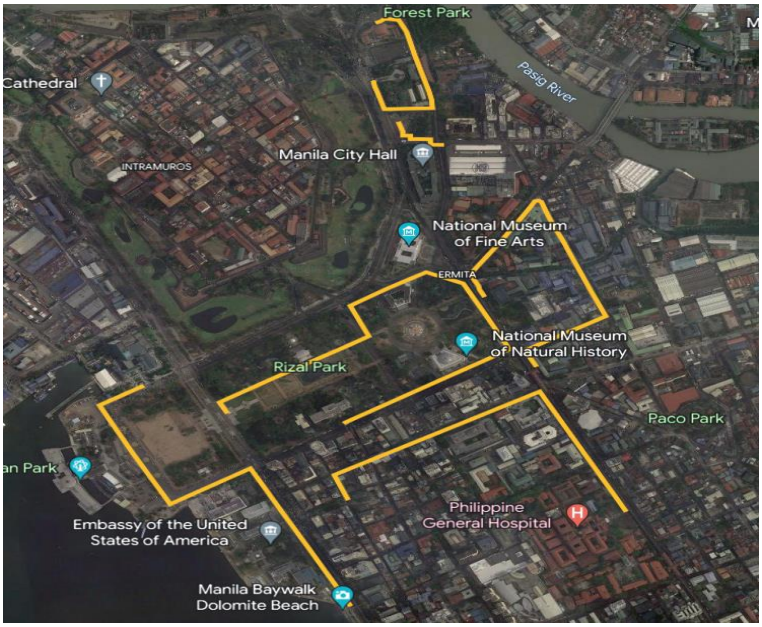


Figure 11. Plotted Routes for AR Heritage Walk using Dijkstra's Algorithm of Google Maps

Table 2 shows the name of the heritage walk and its starting and end point.

Table 2.

Name of Heritage Walk and its Starting and Endpoint

Heritage Walk	Starting point	End point
1. Historical	Metropolitan Theater	Arroceros Forest Park via LRT
2. Seat of Office	Bonifacio Monument	SM Manila
3. School Zone	Santa Isabel College	Araullo High School
4. Park Zone	Rizal Monument	National Library via Taft
5. Seaside	Manila Hotel	Manila Baywalk

6. Government Offices	Ermita Church	Philippine General Hospital

Augmented Reality Coding

AR HOTSPOTS Placing Objects to Places

1. Import all the necessary packages and assets in the Unity Project, which include ARCore, AR Foundation, AR+GPS Location.
2. Import the XML file you downloaded from the web editor into unity.
3. Create AR+GPS Location scene in the hierarchy. Create a new GameObject and add a Web Map Loader component to it.
4. In the Xml Data File property, select the XML file you just imported.
5. Create a PrefabDatabase asset file and edit it in the inspector panel.
6. Add the entries you need. The Mesh Id should match the Mesh Id from the web map editor, and the Prefab is the Prefab/GameObject that you want to associate with the ID.
7. After you are done creating the PrefabDatabase, just add it to the Web Map Loader.

AR HERITAGE WALK

1. Create a MapboxRoute script inside the AR+GPS Location scene.
2. Head over to the tokens section of your mapbox account page, and either create a new token or copy an existing token and paste it on the Mapbox Token property of the MapboxRoute component in the inspector.
3. Create a route in Google Maps that will give the shortest path using Dijkstra's Algorithm. It is where the route starts and where the route ends. It will be automatically obtained from Google Maps using the API or a similar service, and

the extracted data are formatted into a KML file structure. This KML file can then be imported into Google Earth.

4. Import the KML File in the unity project.
5. Assign entries, such as signposts, arrows, and lines, from the prefab database.

This actual script from Unity section presents the loading, parsing, and detection of the content of the XML files which are the coordinates of the places and the startup of AR function.

```
public TextAsset XmlDataFile;
void Start(){ // Start is called before the first frame update
        LoadXmlFile();
        BuildGameObjects();
    }

void LoadXmlFile()
    {
        var xmlString = XmlDataFile.text;
        Debug.Log(xmlString);
        XmlDocument xmlDoc = new XmlDocument();
        try{
          xmlDoc.LoadXml(xmlString);
        }
        catch (XmlException e){
```

```
            Debug.LogError("[ARLocation#WebMapLoader]: Failed to parse XML file: "
        + e.Message);
        }
        var root = xmlDoc.FirstChild;
        var nodes = root.ChildNodes;
        foreach (XmlNode node in nodes){
            Debug.Log(node.InnerXml);
            Debug.Log(node["id"].InnerText);

            int id = int.Parse(node["id"].InnerText);
            double lat = double.Parse(node["lat"].InnerText, CultureInfo.InvariantCulture);
            double lng = double.Parse(node["lng"].InnerText,
CultureInfo.InvariantCulture);
            double altitude = double.Parse(node["altitude"].InnerText,
CultureInfo.InvariantCulture);
            string altitudeMode = node["altitudeMode"].InnerText;
            string name = node["name"].InnerText;
            string meshId = node["meshId"].InnerText;
            float movementSmoothing =
float.Parse(node["movementSmoothing"].InnerText, CultureInfo.InvariantCulture);
            int maxNumberOfLocationUpdates =
int.Parse(node["maxNumberOfLocationUpdates"].InnerText);
            bool useMovingAverage = bool.Parse(node["useMovingAverage"].InnerText);
```

```
            bool hideObjectUtilItIsPlaced =
bool.Parse(node["hideObjectUtilItIsPlaced"].InnerText);


            DataEntry entry = new DataEntry()
            {
               id = id,
               lat = lat,
               lng = lng,
               altitudeMode = altitudeMode,
               altitude = altitude,
               name = name,
               meshId = meshId,
               movementSmoothing = movementSmoothing,
               maxNumberOfLocationUpdates = maxNumberOfLocationUpdates,
               useMovingAverage = useMovingAverage,
               hideObjectUtilItIsPlaced = hideObjectUtilItIsPlaced
            };
            _dataEntries.Add(entry);
            Debug.Log($"{id}, {lat}, {lng}, {altitude}, {altitudeMode}, {name},
{meshId}, {movementSmoothing}, {maxNumberOfLocationUpdates},
{useMovingAverage}, {hideObjectUtilItIsPlaced}");
         }
      }
```

```
}
```

The provided script presents the detection and integration of augmented objects based on the user location.

```
public PrefabDatabase PrefabDatabase;
 void BuildGameObjects(){
          foreach (var entry in _dataEntries){
             var Prefab = PrefabDatabase.GetEntryById(entry.meshId);


             if (!Prefab){
                Debug.LogWarning($"[ARLocation#WebMapLoader]: Prefab
{entry.meshId} not found.");
                continue;
             }


             var PlacementOptions = new PlaceAtLocation.PlaceAtOptions(){
                MovementSmoothing = entry.movementSmoothing,
                MaxNumberOfLocationUpdates = entry.maxNumberOfLocationUpdates,
                UseMovingAverage = entry.useMovingAverage,
                HideObjectUntilItIsPlaced = entry.hideObjectUtilItIsPlaced
             };


             var location = new Location(){
                Latitude = entry.lat,
```

```
            Longitude = entry.lng,
            Altitude = entry.altitude,
            AltitudeMode = entry.getAltitudeMode(),
            Label = entry.name
        };

        var instance = PlaceAtLocation.CreatePlacedInstance(Prefab, location,
    PlacementOptions, DebugMode);

        _placeAtComponents.Add(instance.GetComponent<PlaceAtLocation>());
    }
}
```

Operational and Testing Procedure

The following procedures were followed to operate the AR Functionalities:

1. Download and install the Android Application Package (APK) file to your android phone.
2. Turn on the Location access and Camera Permission on the android phone.
3. Inside the Experience AR module Select the scene that you want to explore (AR Experience or AR Heritage Walk).
4. A. **For AR Experience** – Click the button of your selected place from the 10 AR hotspots in Ermita. Focus the back camera of the Android phone on the vicinity of the designated location then the augmented object will appear. Note that the user

must be precisely positioned in the vicinity location to view the 3D objects; otherwise, the experience will not be as good and augmented object will not appear.

B. **For Routes and Navigation** - Click the button of your selected place from the 10 AR hotspots in Ermita. View the 3D objects which contain augmented lines; follow it until you reach your destination. otherwise, the experience will not be as good.

5. View and observe the behavior of the place with the augmented 3D objects.

The application was subjected to different testing procedures to check and observe if it contains some errors and inconsistencies.

Table 3.

Test Procedures on Functional Suitability of the Application.

Test Case	Steps Undertaken	Expected Results	Types
Experience AR button	a) The user must be in the vicinity of the place of the AR Hotspot. b) Open the application. c) Click the Explore Button. d) Click the Experience AR button. e) Select AR Experience button or AR Heritage walk. f) Select the site of your choice. g) Observe the results.	- It will augment AR objects in the form of information and relevant logos in the vicinity of the designated AR Hotspot or Tourist Site. For AR Experience - It will augment AR objects in the form of 3D lines, arrows, and signposts in the route of the AR Heritage walk. For AR Heritage walk	Functional completeness
AR Experience (AR Hotspot)	a) The user must be in the vicinity of the place of the AR Hotspot. b) Open the application. c) Click the Explore Button. d) Click the Experience AR button. e) Select AR Experience button.	- The AR objects in the AR hotspots will be displayed with precision and dynamism, enhancing user interaction, and enriching their exploration of tourist sites, thereby increasing the app's value for tourists.	Functional Correctness

Test Case	Steps Undertaken	Expected Results	Types
	f) Select the site of your choice. g) Observe the results.		
AR Heritage Walk	a) The user must be in the starting place of the Heritage site. b) Open the application. c) Click the Explore Button. d) Click the Experience AR button. e) Select Heritage button. f) Select the site of your choice. g) Observe the results.	- The AR objects in the AR Heritage walk, such as lines, arrows, and signposts, will be displayed with precision and dynamism along the route, enhancing user interaction and enriching his/her exploration of tourist sites, thus integrating an increase in the app's value for tourists.	Functional Correctness
District of Ermita Module	a) Open the application. b) Click the Explore button. c) Click District of Ermita button. d) A scene that contains visual gallery, history, interactive map button and learn more about Ermita button will display. e) Observe the result by checking each functionality.	- It will display the scene, and all the contents will function properly. The visual gallery will be scrollable, displaying information about the history of Ermita. The buttons, such as the interactive map and "Learn More" about Ermita, will function by transitioning into their respective modules. It will perfectly align its features and functionalities with the specific requirements and objectives of the application.	Functional Appropriateness
Attractions Module	a. Open the application. b. Click the Explore button. c. Click Attractions button. d. A scene will display with different attractions in Ermita will appear. e. Select the attractions you want to choose. f. The attraction panel will appear. g. Observe the results by testing the functionality.	- It will display all the attractions in the scene. When the image is being clicked it will display a panel, an icon will integrate the social media links, website links and will mark the coordinates of the place in google. It will perfectly align its features and functionalities with the specific requirements and objectives of the application.	Functional Appropriateness

Test Case	Steps Undertaken	Expected Results	Types
Emergency Hotline Module	a) Open the application. b) Click the Explore button. c) Click Emergency button. d) A scene of different attractions in Ermita will appear. e) Select the Emergency hotline you want to choose. f) Observe the results by testing the functionality	- It will display all the emergency hotlines in Ermita by buttons and will direct to the dealer. It will perfectly align its features and functionalities with the specific requirements and objectives of the application.	Functional Appropriateness

Table 4.

Test Procedures on Usability of the Application.

Test Case	Steps Undertaken	Expected Results	Types
Experience AR button	a. The user must be in the vicinity of the place of the AR Hotspot. b. Open the application. c. Click the Explore Button d. Click the Experience AR button. e. Select AR Experience button or AR Heritage walk. f. Select the site of your choice. g. Observe the results.	- It will easily augment AR objects in the form of information and relevant logos in the vicinity of the designated easily when in AR Hotspot or Tourist Site. For AR Experience - It will easily augment AR objects in the form of 3D lines, arrows, and signposts in the route of the AR Heritage walk. For AR Heritage walk	Operability
AR Experience (AR Hotspot)	a. The user must be in the vicinity of the place of the AR Hotspot. b. Open the application. c. Click the Explore Button. d. Click the Experience AR button. e. Select AR Experience button. f. Select the site of your choice. g. Observe the results.	- The AR objects in the AR hotspots will not augment or displayed with precision and dynamism, when the user is not within the vicinity or site.	User error protection

Test Case	Steps Undertaken	Expected Results	Types
AR Heritage Walk	a. The user must be in the vicinity of the place of the AR Hotspot. b. Open the application. c. Click the Explore Button. d. Click the Experience AR button. e. Select Heritage button. f. Select the site of your choice. g. Observe the results.	- The AR objects in the AR Heritage walk, such as lines, arrows, and signposts, will not display precisely, when the user is not in the starting point.	User error protection
District of Ermita Module	a. Open the application. b. Click the Explore button. c. Click District of Ermita button. d. A scene that contains visual gallery, history, interactive map button and learn more about Ermita button will display. e. Observe the result by checking each functionality.	- It will display the scene. The visual gallery must be scrollable horizontally. The buttons, such as the interactive map and "Learn More" about Ermita, should be in the same style and theme. The User interface must be visually appealing and meets the user's interaction requirements.	User Interface Aesthetics
Attractions Module	a. Open the application. b. Click the Explore button. c. Click Attractions button. d. A scene will display with different attractions in Ermita will appear. e. Select the attractions you want to choose. f. The attraction panel will appear. g. Observe the results by testing the functionality.	- It will display all the attractions in the scene. Panel, icon, website links, and social media links are all visible. The User interface must be visually appealing and meets the user's interaction requirements.	User Interface Aesthetics
Emergency Hotlines Module	a. Open the application. b. Click the Explore button. c. Click Emergency button. d. A scene of different attractions in Ermita will appear. e. Select the Emergency hotline you want to choose. f. Observe the results by testing the functionality.	- It will display the list of emergency hotlines with simple font style, readable and visible to users. The User interface should be visually appealing and meets the user's interaction requirements.	User Interface Aesthetics

Evaluation Procedure

Statistical method

The weighted mean for each item was computed and the overall weighted mean for each criterion. Then the grand weighted mean was calculated which established the overall acceptability of the application.

Evaluation Instrument

The mobile application underwent evaluation after it was created. A 4-point Likert Scale was the choice for evaluation because respondents are more familiar with it, and it has no neutral point as shown in Table 5.

Table 5.

Range of Weighted Mean Values and its Description

Range	Description
3.26 – 4.00	Highly Acceptable
2.51 – 3.25	Very Acceptable
1.76 - 2.50	Moderately Acceptable
1.00 - 1.25	Not Acceptable

The ErmitARa mobile application was evaluated by 48 respondents comprising different sectors in the community like Tourists, Students, Manila residents, IT Professionals, and Tourism Sector Professional. The evaluation process was as follows:

1. The researchers introduced the developed application system and explained every feature of the application as a guide for the respondents.
2. The researchers provided an evaluation sheet to the respondents and explained the criteria under ISO/IEC 25010 or product quality evaluation system.

3. The respondents answered the evaluation sheet provided using a 4-point Likert scale based on the provided criteria

4. Evaluation sheets were collected and compiled for data collection.

5. The data from each respondent's answered evaluation form were tabulated and used for the computation of the overall frequency and results for each criterion.

6. The results were interpreted using the percentage range shown in Table 5.

Chapter 4

RESULTS AND DISCUSSION

This chapter is composed of the research project description, structure, capabilities and limitations, test results, and evaluation results.

Project Description

ErmitARa is a location-based tourism guide application using augmented reality. It was developed to aid in the tourism sector of the Philippines by providing an application that promotes the tourist destinations in the district of Ermita. It also gives routes and navigation with real-time map viewing. It also provides a page where users can check the most searched and viewed places in Ermita based on application users' preference. This application also provides the user with information such as trivia, a website link, ratings and reviews, and a description of a certain place that was covered.

Project Structure

The project structure contains screenshots and forms used in the application with the descriptions and functions. The layout of the system comprises several activities. The explore button in **Fig. 12** will direct a user to home page as presented in **Fig. 13**

Below are the important buttons of the application:

1. Button 1: Explore in the Landing page.
2. Button 2: Info icon that contains About App.
3. Button 3: DOE (DISTRICT OF ERMITA)
4. Button 4: AR Experience
5. Button 5: Attractions
6. Button 6: Emergency hotlines

Fig 12. Landing Page

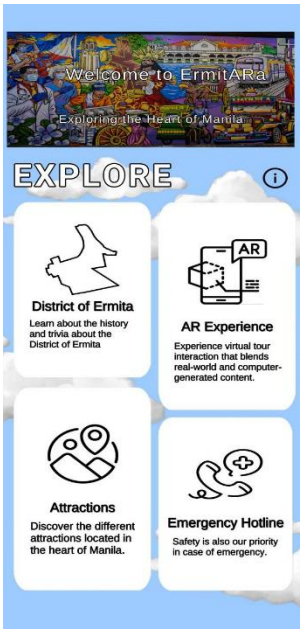


Fig 13. Home

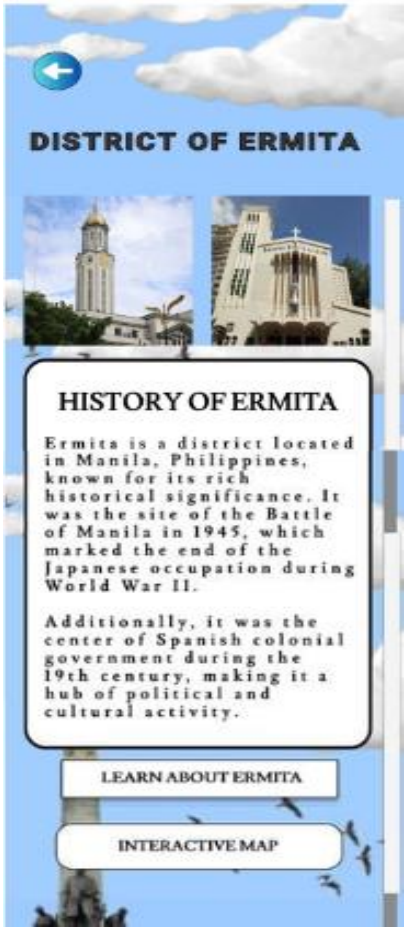


Fig 14. District of Ermita Page

Fig 15. Interactive Map

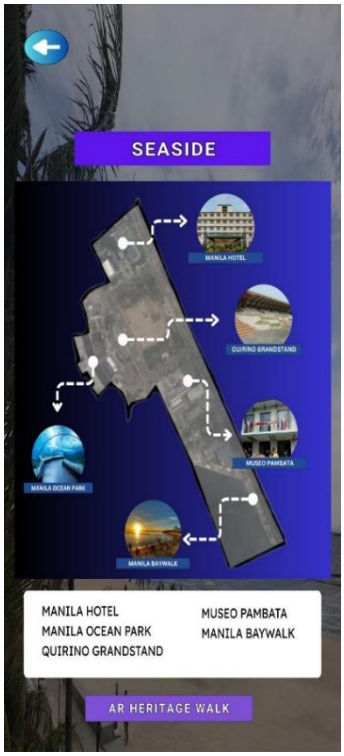


Fig 16. Interactive Map (Seaside)

Fig 17. Interactive Map (Government Offices)

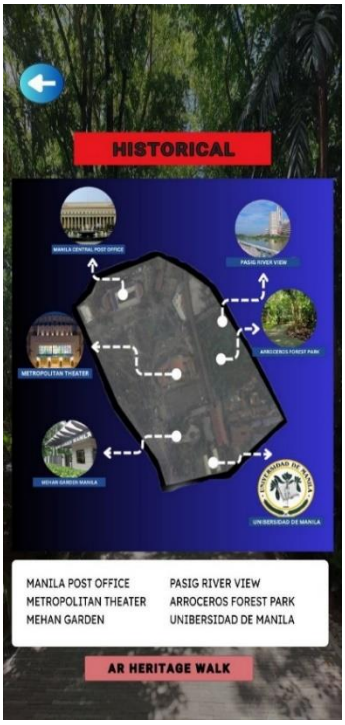


Fig 18. Interactive Map (Historical)

Fig 19. Interactive Map (Seat of Office)

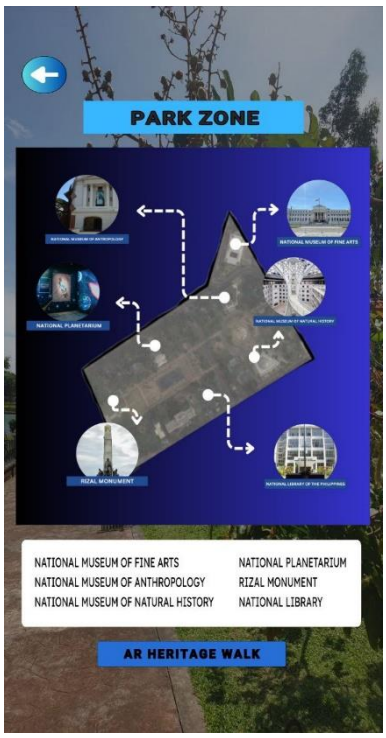


Fig 20. Interactive Map (Park Zone)

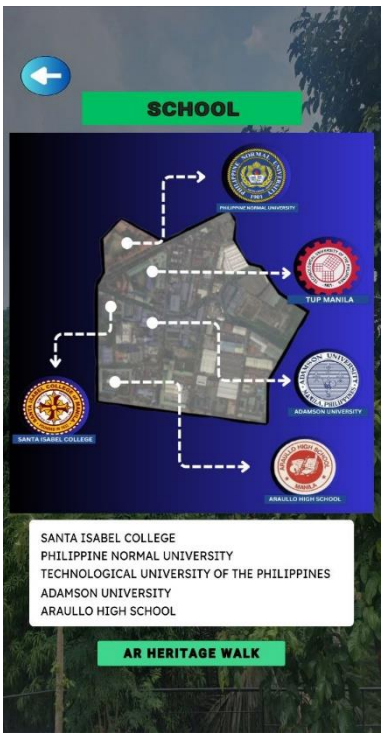


Fig 21. Interactive Map (School Zone)

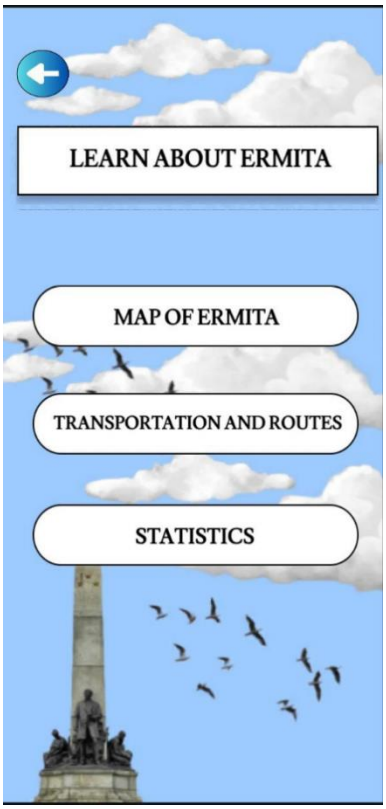


Fig 22. Learn More About Ermita

Fig 23. Manila Map Page

Fig 24. Transportation and Routes Page

Fig 25. Transportation Routes

Fig 26. Statistics Page

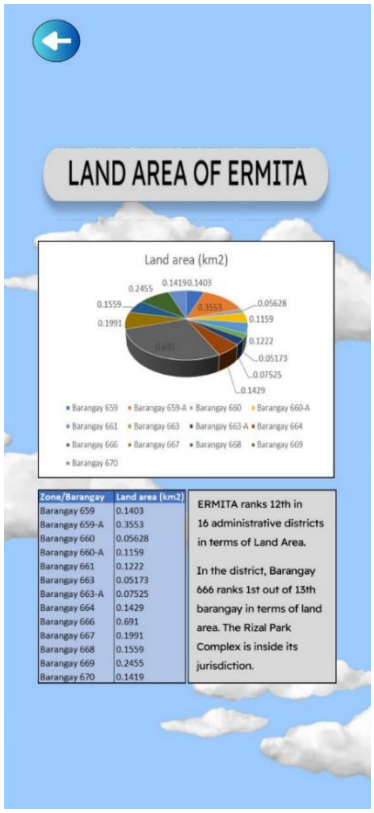


Fig 27. Statistics (Land Area)

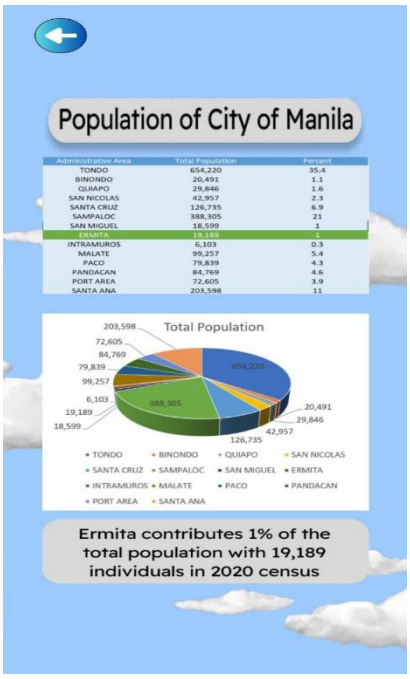


Fig 28. Statistics (Population)

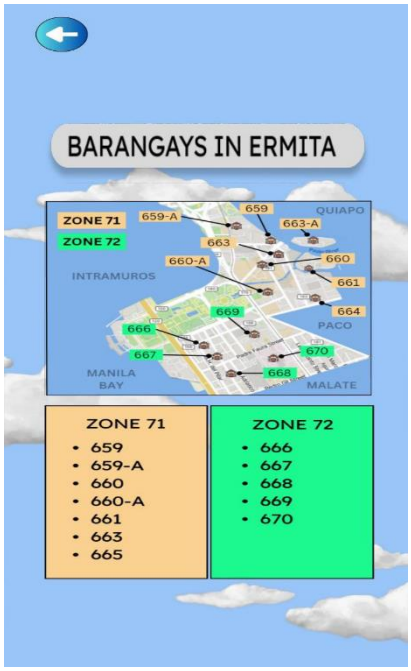


Fig 29. Statistics (Barangays)

Fig 30. Statistics (Important Coordinates)

Buttons in District of Ermita Page

1. Learn more about Ermita
2. Interactive Map

Buttons in Learn More About Ermita Page

1. Manila Map
2. Transportation and Routes
3. Statistics

Buttons in Transportation and Routes Page

1. Yellow
2. Orange
3. Green
4. Red
5. Blue
6. Purple
7. Pink
8. White

Buttons in Statistics Page

1. Land Area
2. Population
3. Barangay
4. Important Coordinates

Fig. 14 displays the District of Ermita page, which includes a gallery, history, and buttons for the interactive map and learning more about Ermita. **Fig. 15** shows an interactive map, and clicking on the icon will transition to the chosen page displayed in **Fig. 16, 17, 18, 19, 20**, and **21**. The Learn More About Ermita Page is depicted in **Fig. 22**, featuring three buttons: Map of Manila, Transportation and Routes, and Statistics. **Fig. 23** displays the map of Manila, while **Fig. 24** and **25** show the scenes for Transportation and Routes and Transportation Routes, respectively. Lastly, **Fig. 26, 27, 28, 29**, and **30** illustrate all the components of the statistics button.

Fig 31. Attractions Page

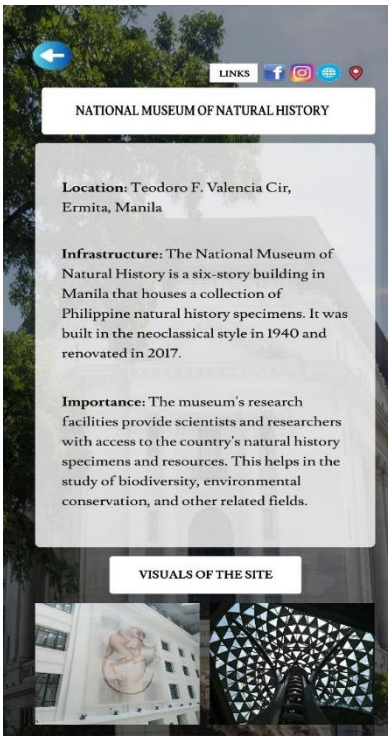


Fig 32. Tourist Site Page

Fig 33. Tourist Site (Social med link Integration)

Fig 34. Tourist Site (Website link Integration)

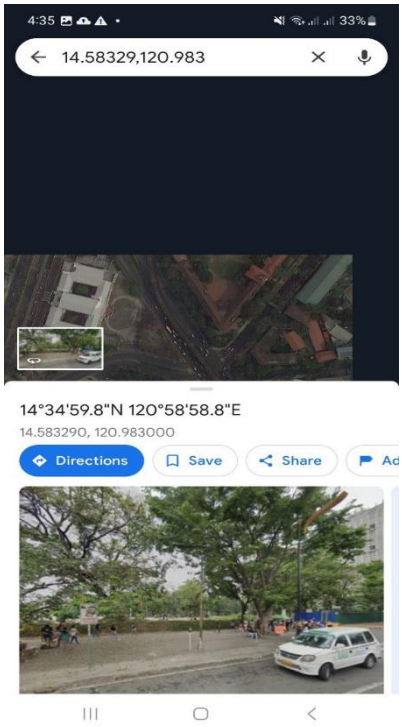


Fig 35. Tourist Site
(Google Maps Integration / Marker Placer)

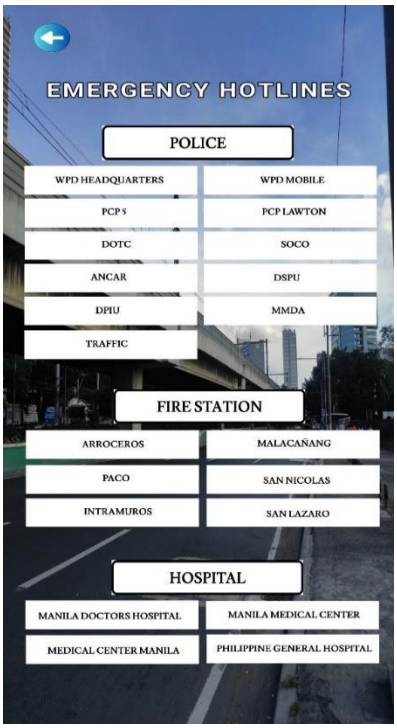


Fig 36. Emergency Hotlines Page

Fig 37. Emergency Hotlines (Dialer integration)

Fig.31 and **Fig. 32** mainly display the attraction page and selected tourist sites in the district. While **Fig. 33** to **Fig. 35** display the integration of social media links, website links and google maps that will appear a marker place in the location. **Fig. 36** and **Fig. 37** are composed of the emergency hotlines in Ermita and a button that will connect the phone dialer to the application.

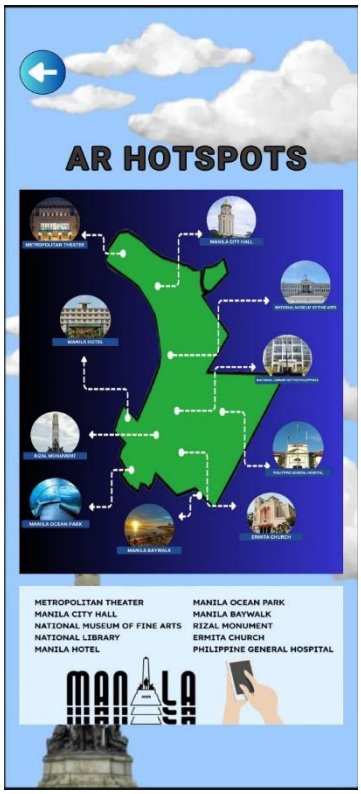


Fig 38. AR Hotspots

Fig 39. Experience AR (Metropolitan Theater)

Fig 40. Experience AR (Manila City Hall)

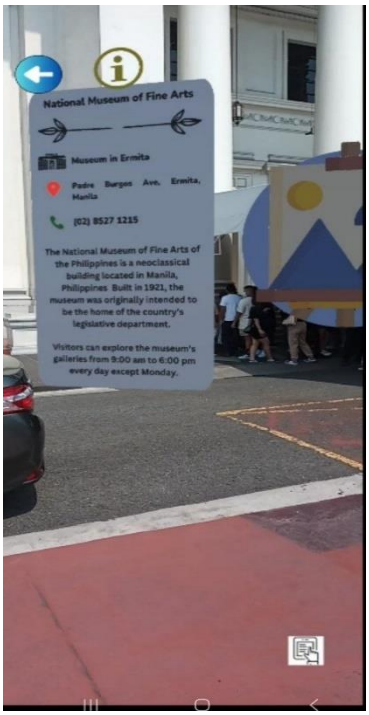


Fig 41. Experience AR (National Museum of Fine Arts)

Fig 42. AR Experience (National Library)

Fig 43. Experience AR (Rizal Monument)

Fig 44. Experience AR (Manila Hotel)

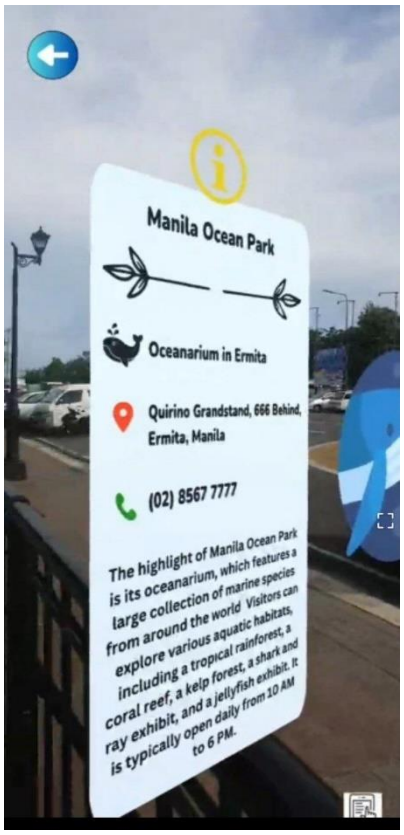


Fig 45. Experience AR (Manila Ocean Park)

Fig 46. Experience AR (Manila Baywalk)

Fig 47. Experience AR (Ermita Church)

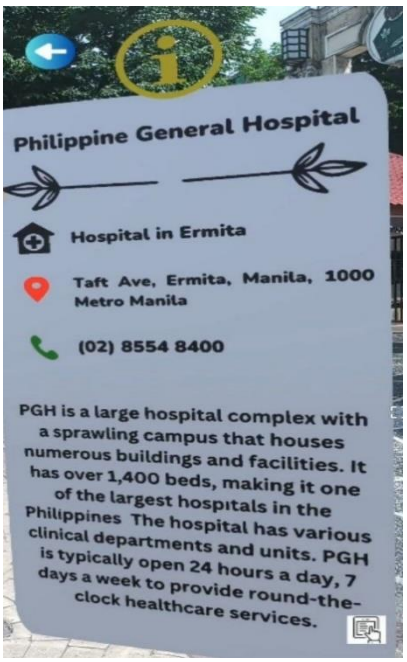


Fig 48. Experience AR (Philippine General Hospital)

Fig 49. AR Heritage Walk (Historical)

Fig 50. AR Heritage Walk (Seat of Office)

Fig 51. AR Heritage Walk (Park Zone)

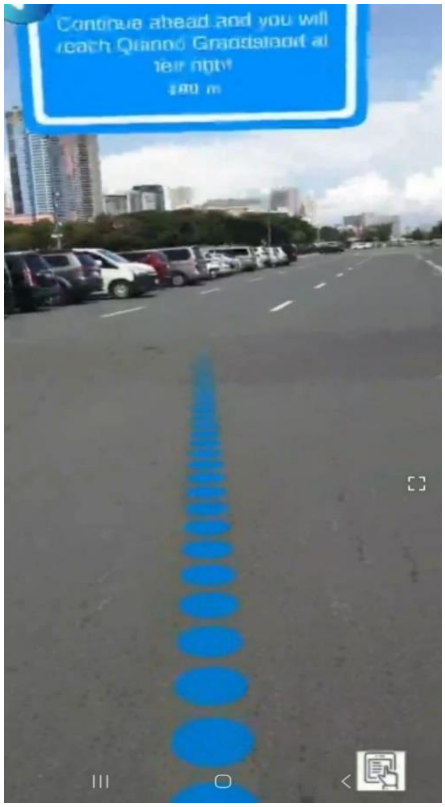


Fig 52. AR Heritage Walk (Seaside)

Fig 53. AR Heritage Walk (Government Offices)

Fig 54. AR Heritage Walk (School Zone)

Project Capabilities and Limitations

ErmitARa has the following capabilities:

1. Display AR object for each tourist destination covered in the list of AR Hotspots.
2. Display AR object in form of outlining AR for each Route covered in the list of AR Heritage walks.
3. Provide information for each tourist destination covered.
4. Transportation routes are being provided.
5. Integration of Social Media links for user reviews and ratings.
6. Integration of Website Links for more information.
7. Integration of Google maps for user direction and navigation in case the user wants to go to the place.

The application's limitations are:

1. The application can only be used in Ermita, Philippines.
2. The application and maps cannot be used offline.
3. The application can only be used in compatible Android phones.
4. The application can only be used on the ground.
5. The application only detects 10 tourist destinations from the District of Ermita for augmented Reality and 6 routes for the AR Heritage Walk.

Table 6.

Test Results on Functional Suitability of the Application

MODULE	STEPS UNDERTAKEN	OBSERVED OUTPUT
(Functional completeness) **Experience AR button**	a) The user must be in the vicinity of the place of the AR Hotspot. b) Open the application. c) Click the Explore Button. d) Click the Experience AR button. e) Select AR Experience button or AR Heritage walk. f) Select the site of your choice. g) Observe the results.	- Displayed an augmented AR object (logo and information) about the AR Hotspots. 3D lines, arrows, and signposts of directions for Routes and Navigation. (See Fig 39. to Fig. 54)
(Functional Correctness) **AR Experience** **(AR Hotspot)**	a) The user must be in the vicinity of the place of the AR Hotspot. b) Open the application. c) Click the Explore Button. d) Click the Experience AR button. e) Select AR Experience button. f) Select the site of your choice. g) Observe the results.	Displayed AR objects in the AR hotspots with precision and dynamism. (See Fig. 39 to Fig. 48)
(Functional Correctness) **AR Heritage Walk**	a) The user must be in the starting place of the Heritage site. b) Open the application. c) Click the Explore Button. d) Click the Experience AR button. e) Select Heritage button. f) Select the site of your choice. g) Observe the results.	Displayed AR objects in the AR Heritage walk, such as lines, arrows, and signposts, with precision and dynamism along the route, enhancing user interaction. (See Fig. 49 to Fig. 54)
(Functional Appropriateness) **District of Ermita Module**	a) Open the application. b) Click the Explore button. c) Click District of Ermita button. d) A scene that contains visual gallery, history, interactive map button and learn more about Ermita button will display. e) Observe the result by checking each functionality.	Displayed the scene, and all the contents functioned properly. The visual gallery was scrollable, displayed information about the history of Ermita. The buttons, such as the interactive map and "Learn More" about Ermita, functioned by transitioning into their respective modules. It was perfectly aligned to its features and functionalities with the specific requirements and objectives of the application. (See Fig. 14 to Fig. 30)

(Functional Appropriateness) **Attractions Module**	a) Open the application. b) Click the Explore button. c) Click the Attractions button. d) A scene will display with different attractions in Ermita will appear. e) Select the attractions you want to choose. f) The attraction panel will appear. g) Observe the results by testing the functionality.	Displayed all the attractions in the scene. Panel, icon, website links, and social media links were all visible. Links were also clickable. (See Fig. 31 to Fig. 35)
(Functional Appropriateness) **EMERGENCY HOTLINES MODULE**	a. Open the application. b. Click the Explore button. c. Click the Emergency button. d. A scene of different attractions in Ermita will appear. e. Select the Emergency hotline you want to choose. f. Observe the results by testing the functionality.	Displayed the list of emergency contact hotlines along Ermita district and hotlines were directed to the phone dial of the device. (See Fig. 36 and Fig. 37)

Table 7.

Test Results on Usability of the Application

MODULE	STEPS UNDERTAKEN	OBSERVED OUTPUT
(Operability) **Experience AR button**	a) The user must be in the vicinity of the place of the AR Hotspot. b) Open the application. c) Click the Explore Button d) Click the Experience AR button. e) Select AR Experience button or AR Heritage walk. f) Select the site of your choice. g) Observe the results.	Displayed an augmented AR objects (logo and information) easily about the AR Hotspots. 3D lines, arrows, and signposts of directions for Routes and Navigation. (See Fig 39. to Fig. 54)
(User Error Protection) **AR Experience** **(AR Hotspot)**	a) The user must be in the vicinity of the place of the AR Hotspot. b) Open the application. c) Click the Explore Button. d) Click the Experience AR button. e) Select AR Experience button. f) Select the site of your choice. g) Observe the results.	AR objects in the AR hotspots did not augment or display with precision and dynamism, when the user was not within the vicinity or site. (See Fig. 39 to Fig. 48)

(User Error Protection) **AR Heritage Walk**	a) The user must be in the starting place of the Heritage site. b) Open the application. c) Click the Explore Button. d) Click the Experience AR button. e) Select Heritage button. f) Select the site of your choice. g) Observe the results.	AR objects in the AR Heritage walk, such as lines, arrows, and signposts, did not display precisely, when the user is not in the starting point. See Fig. 49 to Fig. 54)
(User Interface Aesthetics) **District of Ermita Module**	a) Open the application. b) Click the Explore button. c) Click District of Ermita button. d) A scene that contains visual gallery, history, interactive map button and learn more about Ermita button will display. e) Observe the result by checking each functionality.	Displayed the scene. The visual gallery was scrollable horizontally. The buttons, such as the interactive map and "Learn More" about Ermita, were in the same style and theme. The User interface was visually appealing and meets the user's interaction requirements. (See Fig. 14 to Fig. 30)
(User Interface Aesthetics) **Attractions Module**	a) Open the application. b) Click the Explore button. c) Click the Attractions button. d) A scene will display with different attractions in Ermita will appear. e) Select the attractions you want to choose. f) The attraction panel will appear. g) Observe the results by testing the functionality.	Displayed all the attractions in the scene. Panel, icon, website links, and social media links were all visible. The User interface was visually appealing and meets the user's interaction requirements. See (See Fig. 31 to Fig. 35)
(User Interface Aesthetics) **EMERGENCY HOTLINES MODULE**	a) Open the application. b) Click the Explore button. c) Click the Emergency button. d) A scene of different attractions in Ermita will appear. e) Select the Emergency hotline you want to choose. f) Observe the results by testing the functionality.	Displayed the list of emergency hotlines with simple font style, readable and visible to users. (See Fig. 36 and Fig. 37)

Project Evaluation

The ErmitARa Mobile Application was evaluated to determine its acceptability. The respondents were composed of students, Manila residents, tourists in Ermita, I.T. professionals, and Tourism Sector Professionals. The table below shows the summary of the evaluation results.

Table 8.

Summary of Evaluation Results

Criteria	Weighted Mean	Description
Functional Suitability		
a. Functional completeness	3.44	Highly Acceptable
b. Functional correctness	3.50	Highly Acceptable
c. Functional Appropriateness	3.60	Highly Acceptable
Criterion Weighted Mean	3.51	*Highly Acceptable*
Usability		
a. Operability	3.56	Highly Acceptable
b. User Error Protection	3.33	Highly Acceptable
c. User Interface Aesthetics	3.40	Highly Acceptable
Criterion Weighted Mean	3.43	*Highly Acceptable*
Portability		
a. Installability	3.35	Highly Acceptable
b. Replaceability	3.48	Highly Acceptable
Criterion Weighted Mean	3.42	*Highly Acceptable*
Performance Efficiency		
a. Time Behavior	3.35	Highly Acceptable
b. Resource Utilization	3.44	Highly Acceptable
c. Capacity	3.46	Highly Acceptable
Criterion Weighted Mean	3.42	*Highly Acceptable*
Grand Weighted Mean	**3.44**	***Highly Acceptable***

As can be seen in Table 8, the mobile application ErmitARa received the highest rating in the “Functional Suitability” criterion with a weighted mean of 3.51 described as “Highly Acceptable”, this result indicates that ErmitARa worked as intended to ease the travel experience and time within the vicinity.

With a weighted mean of 3.43 described as "Highly Acceptable," the ErmitARa received its second highest rating in the "Usability" criterion. This means that the mobile application was acceptable as a tool for users to experience an augmented reality scene and learn how objects and real environment interact.

With a weighted mean of 3.42 described as “Highly Acceptable” are the criteria, “Performance Efficiency” and “Portability”, this indicates that accuracy of augmentation and the process of augmentation were acceptable. However, there could be further improvement to other features such as the user can run the application to other devices like Apple and Android (other versions not supported by depth sensors).

To summarize the result, ErmitARa received a grand weighted mean of 3.44 interpreted as “Highly Acceptable”, indicating that as an informative tourism application, it could ease the travel experience of the user within Ermita, Manila.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of findings, the conclusions drawn from the findings, and the corresponding recommendations for further enhancement of the project.

Summary of Findings

The study developed an augmented reality mobile application using Unity, Blender, Visual Studio, and Mapbox SDK.

With the developed application, the innovation of tourism in the district of Ermita will excel and tourists will find the point of interest easier since the app provides details that the user should know about a certain place. It also expands the user experience from the twist of augmented reality in certain places in the district.

In line with the results of the evaluation the application obtained the following findings.

- Test Result
    1. **Functional Suitability.** The test results indicate that the ErmitARa functioned as intended. AR objects and AR Heritage Objects are displayed, and routings of the buttons and pages are in the correct order.
    2. **Usability.** The test results indicate that the ErmitARa is pleasing to the point of view of the user, texts and buttons are in the same style. When the user is not in the right position, AR Objects will not display.
- Evaluation Result

1. **Functional Suitability.** The respondents evaluated the ErmitARa as highly acceptable as how the application worked and helped on less travel time of the user and experience an informative tourist application.
2. **Usability.** The respondents evaluated the ErmitARa as highly acceptable as to the operation of the application, interface aesthetic, appropriateness for the tourist/user need, and interaction of objects to the real environment.
3. **Portability.** The respondents evaluated ErmitARa as highly acceptable as to how it works in selected Android Devices with Depth API.
4. **Performance Efficiency.** The respondents evaluated the ErmitARa as highly acceptable as to its capacity to augment different objects and apply it onto the real environment scene.

Conclusions

Based on the test and evaluation results and findings of the developed application, the following conclusion were derived:

1. The application was successfully designed such that:
    a. It provides educational information about the district that will help the tourism industry.
    b. It displayed augmented 3D objects, such as relevant logos or images in AR Hotspots.

c. It implemented augmented pop-up information pertaining to the location of the AR Hotspots.

d. It implemented Outlining Augmented Reality (AR) in AR Heritage Walks.

e. It directed the app to Social Media API links of the sites for user sharing and reviews.

f. It directed the application to the site's website for more user information.

g. It directed to google maps for user guidance and navigation if tourists want to go to the desired locations.

h. It provided a list of emergency services information around the district of Ermita with connection to the phone dialer when the button is clicked.

i. It displayed a Gallery of compiled photos of the attractions in Ermita.

2. The application was successfully developed and achieved its efficiency with the following requirements.

a. ARCore Software Development Kit of Google Play services v4.2.7

b. ARFoundation v4.2.7

c. Blender v3.3.1

d. Unity v2021.3.16f1 // 3.13f1

e. Unity AR+GPS Location assets v3.6.0

f. Node.js v18.10.0

g. Java Development Kit v17.05.0

h. Gradle v7.6

i. Google Maps Services

j. Google Earth

k. Mapbox API for Unity SDK

l. Android v7.0 or newer for google play, v8.1 (API 27) for android device emulators.

3. Test results showed that the application is functional and usable.
4. The application performed very well and was rated Highly Acceptable by the respondents in terms of performance efficiency, functional suitability, usability, and portability which proves that the application is very helpful in promoting local tourism and improve the smart tourism industry in the District of Ermita.

Recommendations

The following are the recommendations of the study for further improvement of the application:

1. Make the fonts professional.
2. Replace with higher quality images and coordinate with the Department of Tourism (DOT) Office.
3. Provide AR Heritage Walk for alleys.
4. Create accounts for users and provide security for it.
5. Create a warning if the user will cross the street in the Heritage walk.
6. Provide AI Itinerary Generator for tourists.
7. Provide comfort room finder.
8. Provide real time Weather Data.
9. Provide District Restaurant Ratings, Blogs, and Food Reviews main user experience.
10. Provide Online Brochure for Maps.

11. Provide Transportation Fares and Destination Stops.
12. Provide ErmitARa's hotspots expansion to other significant places in Ermita.
13. Provide Augmented 3D humans like heroes explaining districts in Ermita through Sound effects.
14. Make the application compatible to any mobile operating system such as iOS.

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Zhu, Z., He, L., & Wei, X. (2020). Marker-Less Location-Based Augmented Reality Using Artificial Intelligence. *In Proceedings of the 5th International Conference on Intelligent Systems, Metaheuristics & Swarm Intelligence* , 47-54.

Zola, A. (2022, September). *Google Maps*. Retrieved from Tech Target: https://www.techtarget.com/whatis/definition/Google-Maps

Appendix A

EVALUATION INSTRUMENT

1. **Email ***

_____

2. **Name ***

_____

3. **Do you agree to participate in this study? ***

Mark only one oval.

- ◯ Yes
- ◯ No

4. **What role do you take in this study? ***

Mark only one oval.

- ◯ Tourist in Ermita
- ◯ Student
- ◯ Manila Resident
- ◯ IT Professional
- ◯ Tourism Sector Professional

Functional Suitability

This characteristic represents the degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions.

The functionalities integrated into the AR application encompass all the specified tasks and user objectives outlined in tourism applications. ***(Functional completeness)***

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

The AR application precisely augments AR objects in the vicinity of the designated AR Hotspot or Tourist Site. ***(Functional correctness)*** *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

The AR application accurately augments lines, arrows, and signposts to outline the AR experience in the AR Heritage Walk.***(Functional correctness)*** *

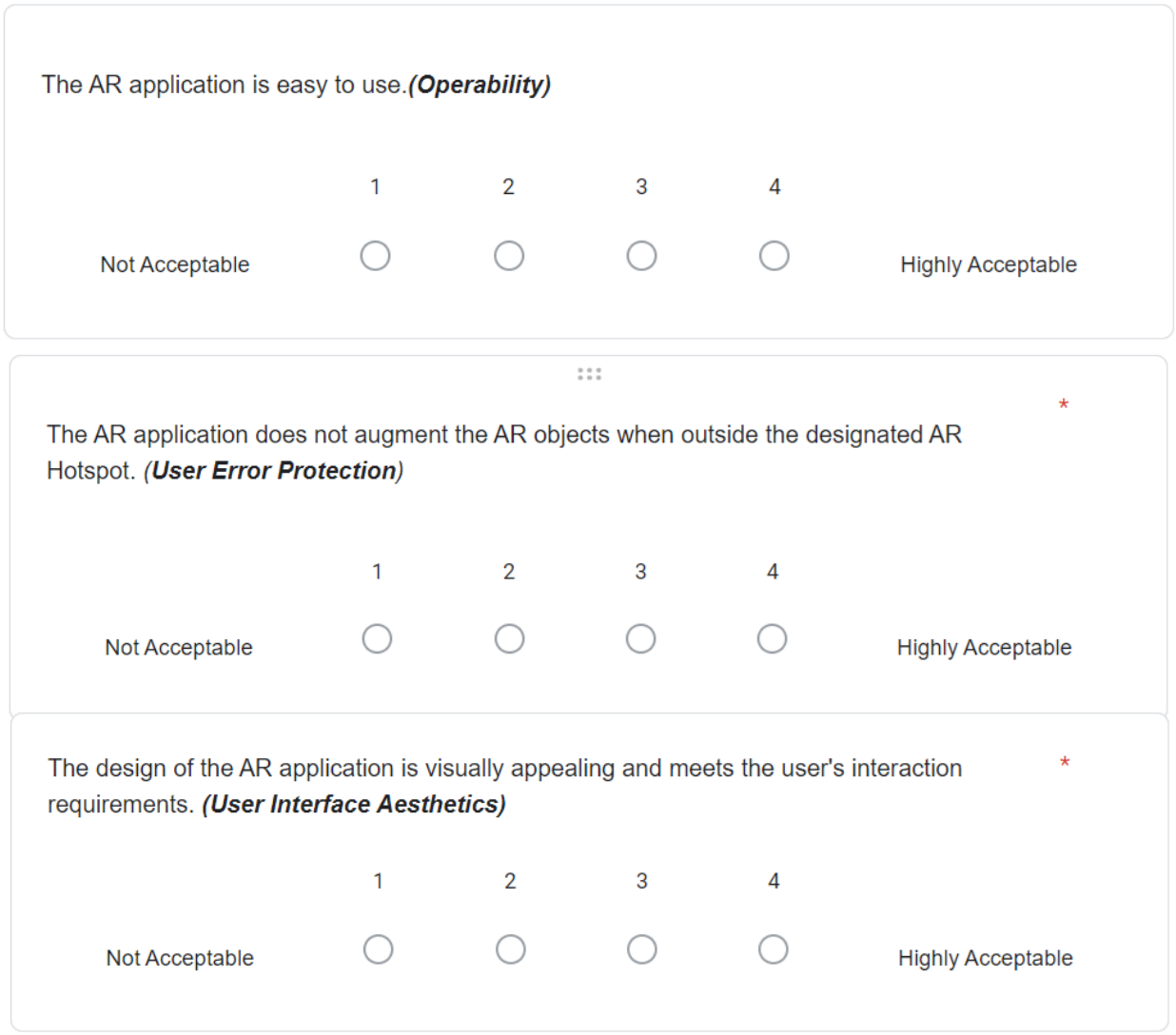
	1	2	3	4	
Not Accepatable	○	○	○	○	Highly Acceptable

The AR application ensure that the features and functionalities aligned with the application's requirements and objectives, supporting the implementation of intended tasks, user interactions, and overall goals in the AR experience. ***(Functional Appropriateness)*** *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

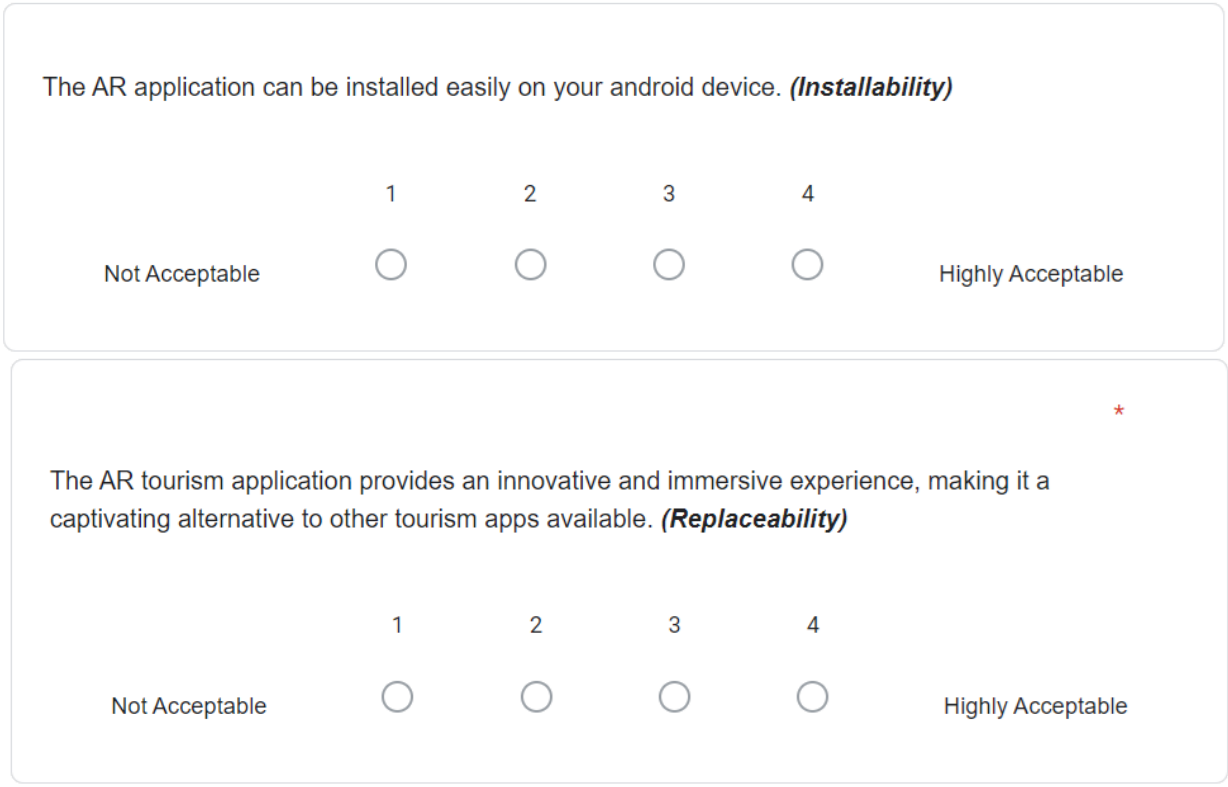
Usability

Degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.



Portability

Degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another.



Performance Efficiency

This characteristic represents the performance relative to the amount of resources used under stated conditions.

The AR application can accurately augment objects and promptly respond to user interactions.***(Time Behavior)***

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

The AR tourism app uses resources efficiently and appropriately, considering both the quantity and types of resources utilized. ex. power and data storage ***(Resource Utilization)*** *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

The AR application has reasonable maximum limits for processes.***(Capacity)*** *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

Comments and Suggestions

If you have any comments, suggestions, or other recommendations, please do not hesitate to share them with us. Thank you for participating in our survey!

Appendix B

SAMPLE ANSWERED EVALUATION SHEET

Email *

☐ Record my email address with my response

Name *

Kayshia Malunes

Do you agree to participate in this study? *

◉ Yes

○ No

What role do you take in this study? *

○ Tourist in Ermita

◉ Student

○ Manila Resident

○ IT Professional

Functional Suitability

This characteristic represents the degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions.

The functionalities integrated into the AR application encompass all the specified tasks and user objectives outlined in tourism applications. ***(Functional completeness)***

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

The AR application precisely augments AR objects in the vicinity of the designated AR Hotspot or Tourist Site. ***(Functional correctness)*** *

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

The AR application accurately augments lines, arrows, and signposts to outline the AR experience in the AR Heritage Walk.***(Functional correctness)*** *

	1	2	3	4	
Not Accepatable	○	○	○	◉	Highly Acceptable

The AR application ensure that the features and functionalities aligned with the application's requirements and objectives, supporting the implementation of intended tasks, user interactions, and overall goals in the AR experience. ***(Functional Appropriateness)*** *

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Usability

Degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.

The AR application is easy to use.***(Operability)***

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

The AR application does not augment the AR objects when outside the designated AR Hotspot. *(**User Error Protection**)* *

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

The design of the AR application is visually appealing and meets the user's interaction requirements. ***(User Interface Aesthetics)*** *

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Portability

Degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another

The AR application can be installed easily on your android device. ***(Installability)***

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

*

The AR tourism application provides an innovative and immersive experience, making it a captivating alternative to other tourism apps available. ***(Replaceability)***

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Performance Efficiency

This characteristic represents the performance relative to the amount of resources used under stated conditions.

The AR application can accurately augment objects and promptly respond to user interactions.***(Time Behavior)***

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

The AR tourism app uses resources efficiently and appropriately, considering both * the quantity and types of resources utilized. ex. power and data storage ***(Resource Utilization)***

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

The AR application has reasonable maximum limits for processes.***(Capacity)*** *

	1	2	3	4	
Not Acceptable	○	○	○	◉	Highly Acceptable

Comments and Suggestions

If you have any comments ,suggestions or other recommendations, please do not hesitate to share them with us. Thank your for participating in our survey!

If possible, display trivia while going to the des

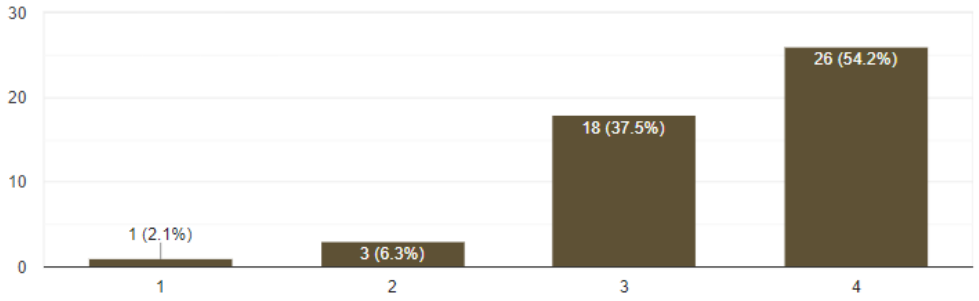
RESULT SHEET

Functional Suitability

The functionalities integrated into the AR application encompass all the specified tasks and user objectives outlined in tourism applications. ***(Functional completeness)***

Copy

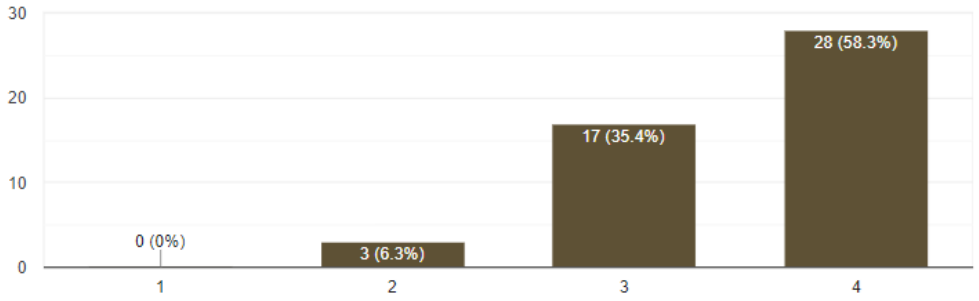
48 responses



Given in the demonstration the AR application precisely augments AR objects in the vicinity of the designated AR Hotspot or Tourist Site. ***(Functional correctness)***

Copy

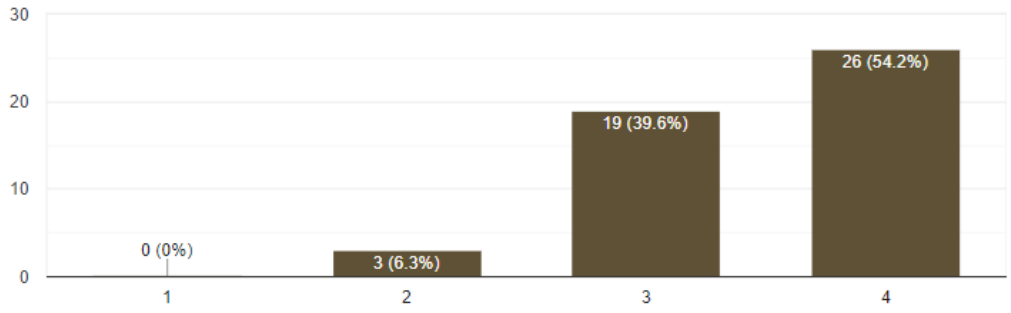
48 responses



Given in the demonstration the AR application accurately augments lines, arrows, and signposts to outline the AR experience in the AR Heritage Walk.***(Functional correctness)***

Copy

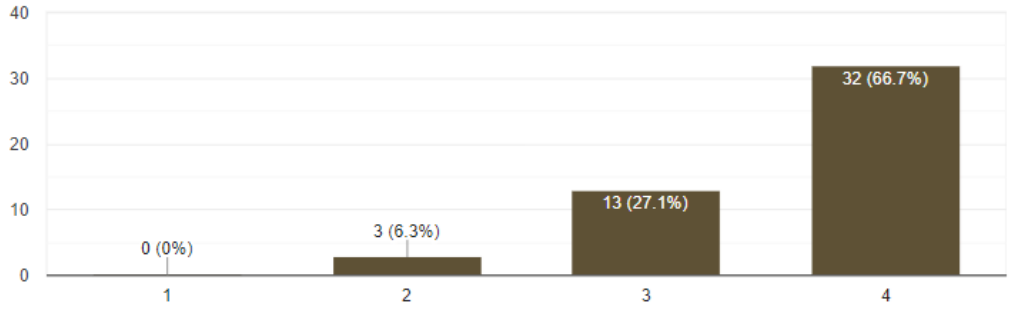
48 responses



Given in the demonstration the AR application ensured that the features and functionalities aligned with the application's requirements and objectives, supporting the implementation of intended tasks, user interactions, and overall goals in the AR experience. ***(Functional Appropriateness)***

Copy

48 responses



Usability

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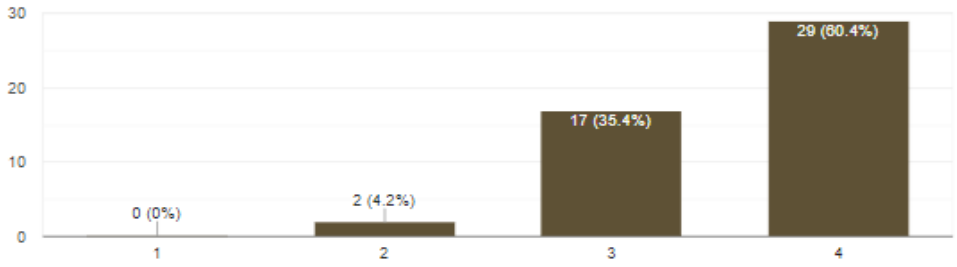
The AR application is easy to use.***(Operability)***

48 responses



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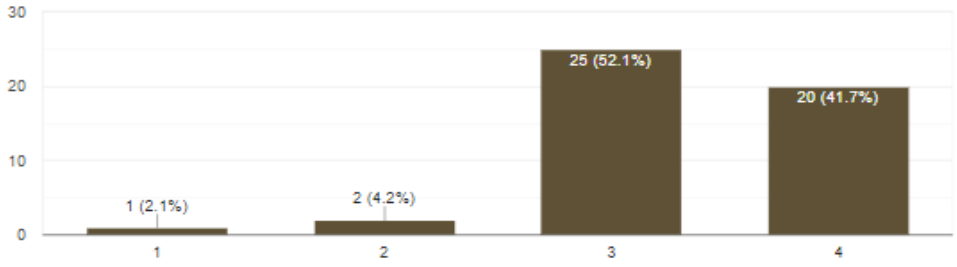
The AR application does not augment the AR objects when outside the designated AR Hotspot and stand still on the vicinity. ***(User Error Protection)***

48 responses



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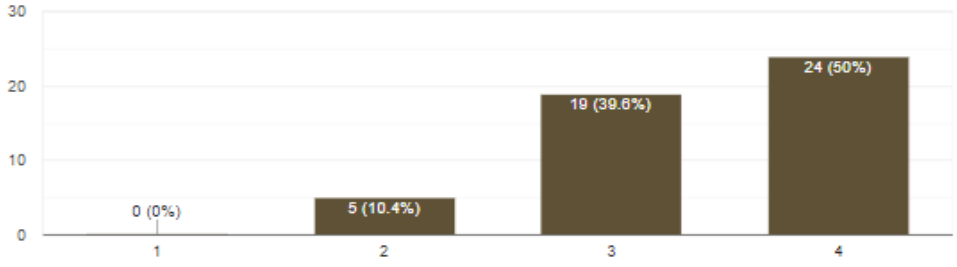
The design of the AR application is visually appealing and meets the user's interaction requirements. ***(User Interface Aesthetics)***

48 responses

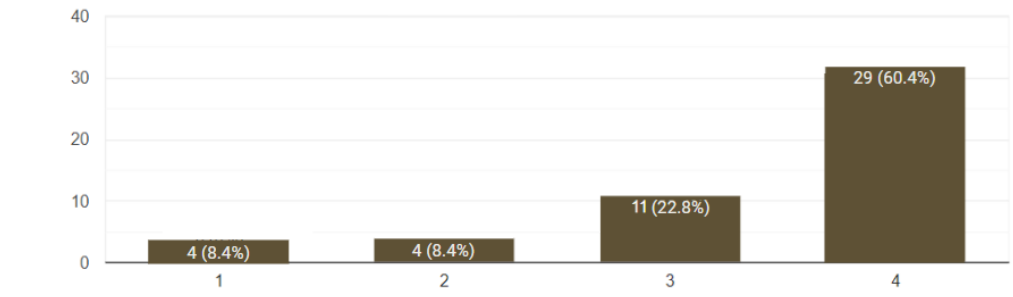


Portability

Copy

Given in the demonstration the AR application can be installed easily on android devices except in devices that did not meet the requirements. ***(Installability)***

48 responses



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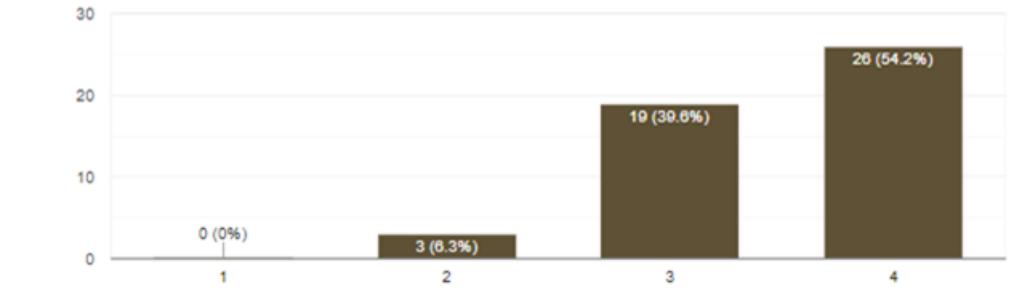
Given in the demonstration the AR tourism application we created provides an innovative and immersive experience, making it a captivating alternative to other tourism apps available. ***(Replaceability)***

48 responses

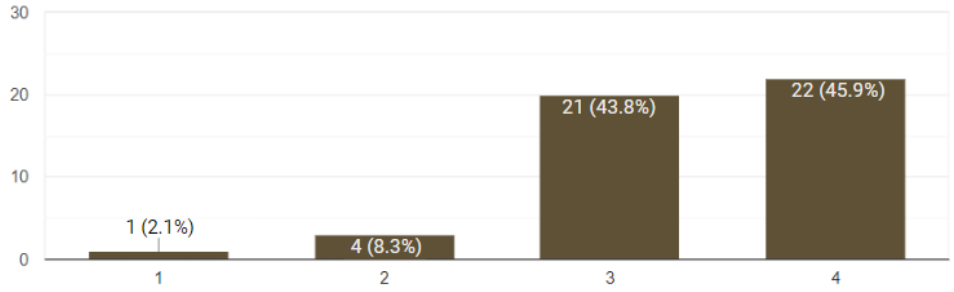


Performance Efficiency

Copy

Given in the demonstration the AR application can accurately augment objects and promptly respond to user interactions.***(Time Behavior)***

48 responses



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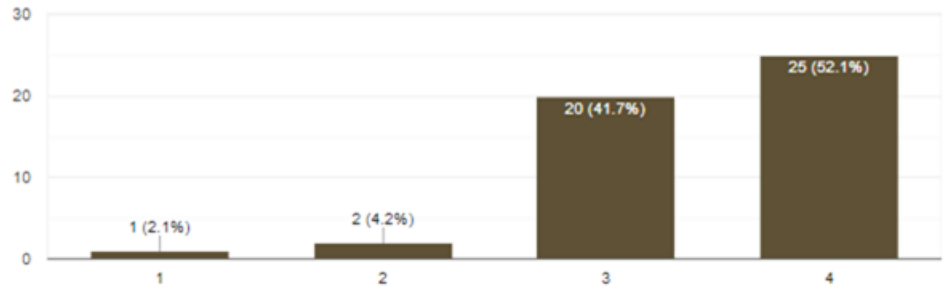
Given in the demonstration the AR tourism app uses resources efficiently and appropriately, considering both the quantity and types of resources utilized. ex. power and data storage ***(Resource Utilization)*** for information the data or internet will only be used in integration Soc Med API.

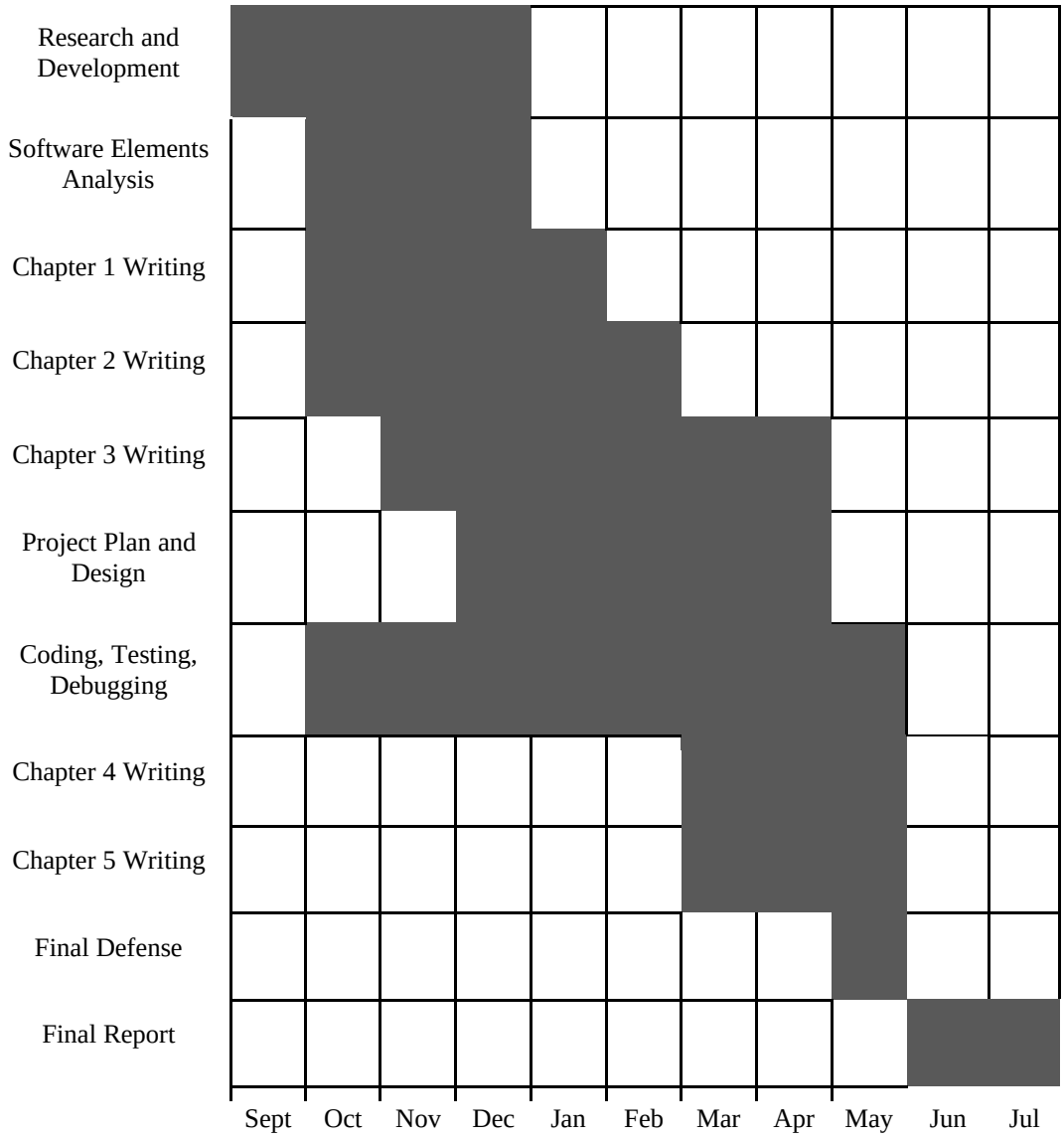
48 responses



Appendix C
SUMMARY OF EVALUATION RESPONSES

Design Criteria	1	2	3	4
Functionality				
1. Functional Completeness	**1**	**3**	**18**	**26**
2. Functional Correctness	**0**	**3**	**17**	**28**
3. Functional Correctness	**0**	**3**	**19**	**26**
4. Functional Appropriateness	**0**	**3**	**13**	**32**
Usability				
1. Operability	**0**	**2**	**17**	**29**
2. User Error Protection	**1**	**2**	**25**	**20**
3. User Interface Aesthetics	**0**	**5**	**19**	**24**
Portability				
1. Installability	**4**	**4**	**11**	**29**
2. Replaceability	**0**	**3**	**19**	**26**
Performance Efficiency				
1. Time Behavior	**1**	**4**	**21**	**22**
2. Resource Utilization	**1**	**2**	**20**	**25**
3. Capacity	**0**	**4**	**18**	**26**

Appendix D
GANTT CHART



Appendix E

USER'S MANUAL

A. Explore

To access the Home Page of the app, follow these steps:

1. Launch the ErmitARa app on your mobile device.
2. Click the Explore button.
3. You will be directed to the Home Screen.

B. Welcome Banner

To view details about the ErmitARa app, follow these steps:

1. On the Home screen, locate the Welcome Banner located on the upper screen of the app.
2. Tap on it to see more information about the ErmitARa app.

C. District of Ermita

To learn more about the District of Ermita and explore its features, follow these steps:

1. On the Home screen of the app, locate and click the "District of Ermita" button.
2. Upon clicking the button, you will be presented with a carousel gallery showcasing images related to Ermita. Next is its brief history.
3. To access more detailed information and interactive features, scroll down on the screen.
4. Below, you will find two buttons: "Learn More About Ermita" and "Ermita Interactive Map."

District of Ermita - Learn More About Ermita

To learn more about the district of Ermita and access related information, follow these steps:

1. On the Home screen, you will find the section labeled "District of Ermita."
2. Tap on the "District of Ermita" section to proceed.
3. On the District of Ermita page, you will find the option "Learn More About Ermita." Tap on it.
4. After selecting "Learn More About Ermita," three buttons will appear (Map of Manila, Transportation and Routes, and Statistics).

5. **Map of Manila:**

    a. Tap on the "Map of Manila" button.
    b. A map of Manila will be displayed, along with a list of districts.

    Transportation and Routes:

    a. To access transportation and route information for Ermita, go back to the "Learn More About Ermita" page.
    b. Tap on the "Transportation and Routes" button.
    c. A comprehensive list will be displayed, showing the available transportation options in Ermita and their respective routes.

    Statistics:

    a. Return to the "Learn More About Ermita" page.
    b. Tap on the "Statistics" button.
    c. Information related to the population, land area, coordinates, and barangays of Ermita will be presented.

D. District of Ermita – Ermita Interactive Map

To explore the Ermita district through the interactive map feature, follow these steps:

1. On the District of Ermita page, locate the "Ermita Interactive Map" button positioned in the lower part of the screen.
2. Tap on the "Ermita Interactive Map" button to access the interactive map.
3. Upon opening the interactive map, you will be presented with a mini map of Ermita, featuring different categories distinguished by their respective colors and icons. These categories include Historical, Seat of Office, School Zone, Park Zone, Government Office, and Seaside.
4. Each category is clickable. To explore a specific category, tap on your desired one.
5. Once you click on a category, a new mini map will appear, showcasing circular buttons representing the various places within that category.
6. Select one of the places on the mini map by tapping on its corresponding button. This action will display detailed information about the chosen location. The information may include the address, infrastructure, importance, visuals of the site, as well as links to social media accounts, the website, and coordinates in Google Maps.
7. To navigate back to the category's mini map, use the provided navigation options.

8. Additionally, a list of places within the selected category will be displayed on the lower part of the screen.
9. Below the list of places, you will find a button labeled "AR Heritage Walk." For more information about this feature, please refer to the User's Manual section on AR Experience - AR Heritage Walk.

E. Attractions

The ErmitARa mobile app provides you with a convenient way to discover interesting places in Ermita. Follow the steps below to explore the attractions and access detailed information about each place.

1. On the Home Screen, locate the "Attractions" button.
2. Tap on the "Attractions" button to proceed.
3. A list of nearby attractions will be displayed on the screen as buttons.

Selecting an Attraction:

a. Browse through the list of attractions and tap on the button corresponding to the attraction you are interested in.
b. After selecting an attraction, the app will display detailed information about that place, including its location, infrastructure, and importance.
c. In the upper-right corner of the screen, you will find the social media accounts associated with the attraction, a website link (if available), and the coordinate of the place in Google Maps. You can use these links to access additional information or connect with the attraction through social media.
d. At the bottom of the screen, you will find a mini gallery showcasing images of the location.

F. Emergency Hotlines

The ErmitARa mobile app provides a dedicated section for accessing emergency hotlines. Follow the steps below to navigate to the Emergency Hotline button and contact the desired emergency service.

1. Locate the "Emergency Hotline" button on the Home screen.
2. Tap on the "Emergency Hotline" button to proceed.
3. A list of emergency hotlines will be displayed, categorized by Police, Fire Station, and Hospital.

Selecting a Hotline:

a. Browse through the list and identify the specific hotline you need to contact based on the emergency situation.

b. Once you have identified the desired hotline, tap on the telephone number associated with that service.

Initiating the Call:

Tapping the telephone number will initiate a call using your mobile device's call feature.

a. Your mobile device's call screen will be displayed, and the selected emergency hotline number will be dialed automatically.
b. Follow the instructions on your mobile device's call screen to complete the call to the emergency service.

G. AR Experience

The ErmitARa mobile app offers an exciting Augmented Reality (AR) experience to enhance your exploration of Ermita. Follow the steps below to access and navigate the AR Experience feature within the app.

1. Locate the "AR Experience" button on the Home Screen.
2. Tap on the "AR Experience" button to proceed.
3. Three buttons will appear: AR Hotspots, Explore AR, and AR Heritage Walk.

Information and Instructions:

a. In the upper right corner of the three buttons, you will find an information icon button. Tap on this icon.
b. The app will display instructions and information about the three buttons. Additionally, it will present a list of 10 AR Hotspots and the routes for the AR Heritage Walk.
c. To close the information icon, tap on the X button located on the upper right corner of the Instructions.

H. AR Experience - AR Hotspots

1. Tap on the "AR Hotspots" button to explore the available AR experiences.
2. A mini map will be displayed, showing the locations of the 10 AR Hotspots.
3. Below the mini map, you will find a list of the 10 hotspots.

Selecting a Hotspot:

a. On the mini map, tap on one of the location hotspots you wish to explore further.
b. Detailed information about the selected place will be shown, similar to the information provided in the Attractions section of the app.

I. AR Experience – Explore AR

The Explore AR feature in the ErmitARa mobile app allows you to discover AR Objects and information about specific locations. Follow the steps below to use the Explore AR functionality.

Important Note:

Please keep in mind that the ErmitARa app is only intended to run on Android devices that have ARCore services, commonly known as Google Play Services for AR, installed. It is important to ensure that your device meets these requirements, including support for depth sensors and OpenGL ES, to fully utilize the AR features of the app. For a comprehensive list of ARCore-supported devices, you can visit this link: https://developers.google.com/ar/devices

1. Ensure that you are physically located at one of the AR Hotspots you wish to explore.
2. On the AR Experience page, locate and tap the "Explore AR" button.
3. A prompt will appear requesting permission to access your device's camera and GPS (location). Grant the necessary permissions to proceed.
4. Once permissions are granted, the camera screen will be displayed on your device.

Scanning for AR Objects:

a. Hold your device in front of you and scan your surroundings by moving the camera.
b. As you scan, the app will search for AR objects.
c. When an AR object is detected, it will appear on your device's screen as a box container with information about the place and an accompanying icon picture.

Instructions for Explore AR:

a. To access instructions for using the Explore AR feature, look for the lower-right bottom of the screen.
b. Tap on the instruction icon located in that area to view detailed instructions on how to navigate and use the Explore AR feature.

J. AR Experience – AR Heritage Walk

The AR Heritage Walk feature in the ErmitARa mobile app allows you to embark on a virtual heritage tour of Ermita. Follow the steps below to use the AR Heritage Walk and explore different categories of places.

Important Note:

Before starting the AR Heritage Walk, make sure that you are physically located at the first location of any category you wish to explore. It is important to start at the specified first location to ensure optimal functionality of this feature. If you begin at a different location, the AR Heritage Walk may not function correctly.

Exiting the app during the AR Heritage Walk will cause the tour to restart from the beginning. This means you will need to go back to the first location. Therefore, it is recommended to complete the entire tour without exiting the app to maintain the continuity of your progress.

Please keep in mind that the ErmitARa app is only intended to run on Android devices that have ARCore services, commonly known as Google Play Services for AR, installed. It is important to ensure that your device meets these requirements, including support for depth sensors and OpenGL ES, to fully utilize the AR features of the app. For a comprehensive list of ARCore-supported devices, you can visit the following link: https://developers.google.com/ar/devices

1. On the AR Experience page, locate and tap on the "AR Heritage Walk" button.
2. After clicking the "AR Heritage Walk" button, six yellow buttons will appear below it, representing different categories of places.
3. Each button corresponds to a specific category, namely: Seaside, Government Office, Historical, Park Zone, School Zone, and Seat of Office.
4. Tap on the button representing the category you wish to explore within the AR Heritage Walk.
5. A prompt will appear requesting permission to access your device's camera and GPS (location). Grant the necessary permissions to proceed.
6. Once permissions are granted, the camera screen will be displayed on your device.

Navigating the AR Heritage Walk:

a. On the camera screen, you will see an arrow and a note in the banner. Follow the arrow and the note to see the direction and distance to the next location within the selected category.
b. Move your device around and follow the on-screen guidance to navigate to each point of interest.

Instructions for AR Heritage Walk:

a. In the lower-right corner of the screen, you will find instructions on how to properly use the AR Heritage Walk feature. Tap on the instructions icon to view detailed instructions and guidance.

Appendix F

THESIS GRAMMARIAN CERTIFICATION

	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines Tel No. +632-5301-3001 local 608| Fax No. +632-8521-4063 Email: cos@tup.edu.ph | Website: www.tup.edu.ph	Index No.	REF-COS-3.5-INT-TGC
		Revision No.	00
		Effectivity Date	06132022
VAA-COS	**THESIS GRAMMARIAN CERTIFICATION**	Page	1 / 1

THESIS GRAMMARIAN CERTIFICATION

This is to certify that the thesis entitled,

ErmitARa: AN ANDROID-BASED AUGMENTED REALITY MOBILE APPLICATION FOR GUIDED HERITAGE WALKS AND INFORMATIVE 3D DISPLAY FOR HISTORICAL AND LOCAL TOURIST ATTRACTIONS

Authored by

Malunes, Kayshia Princess M.
Perminola, John Paulo I.
Tario, Marielle Louise B.

has undergone editing and proofreading by the undersigned.

This Certification is being issued upon the request of Kayshia Princess M. Malunes, John Paulo I. Perminola, Marielle Louise B. Tario for whatever purposes it may serve them.

Prof. Marilyn M. Ignacio
Grammarian

Technological University of the Philippines

Date of Issuance

Transaction ID	
Signature	

Appendix G

CERTIFICATE OF SIMILARITY INDEX USING TURNITIN FROM URDS

	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines Tel No. +632-301-3001 local 711 Email: urds@tup.edu.ph | Website: www.tup.edu.ph	Index No.	F-URD-4.1-CSI
		Issue No.	01
		Revision No.	00
		Date	06162023
VRE-URD	**CERTIFICATE OF SIMILARITY INDEX USING TURNITIN**	Page	1 / 1
		QAC No.	CC-06162023

This is to certify that the manuscript entitled

"AN ANDROID-BASED AUGMENTED REALITY MOBILE APPLICATION FOR GUIDED HERITAGE WALKS AND INFORMATIVE 3D DISPLAY OF HISTORICAL AND LOCAL TOURIST ATTRACTIONS"

Authored by

KAYSHIA PRINCESS M. MALUNES
JOHN PAULO I. PERMINOLA
MARIELLE LOUISE B. TARIO

College of Science

has been subjected to similarity check on June 16, 2023
using Turnitin with generated similarity index of **10%**.

Processed by:

Assoc. Prof. FRANCIS A. ALFARO, Ed.D., LPT
Faculty, University Research
and Development Services

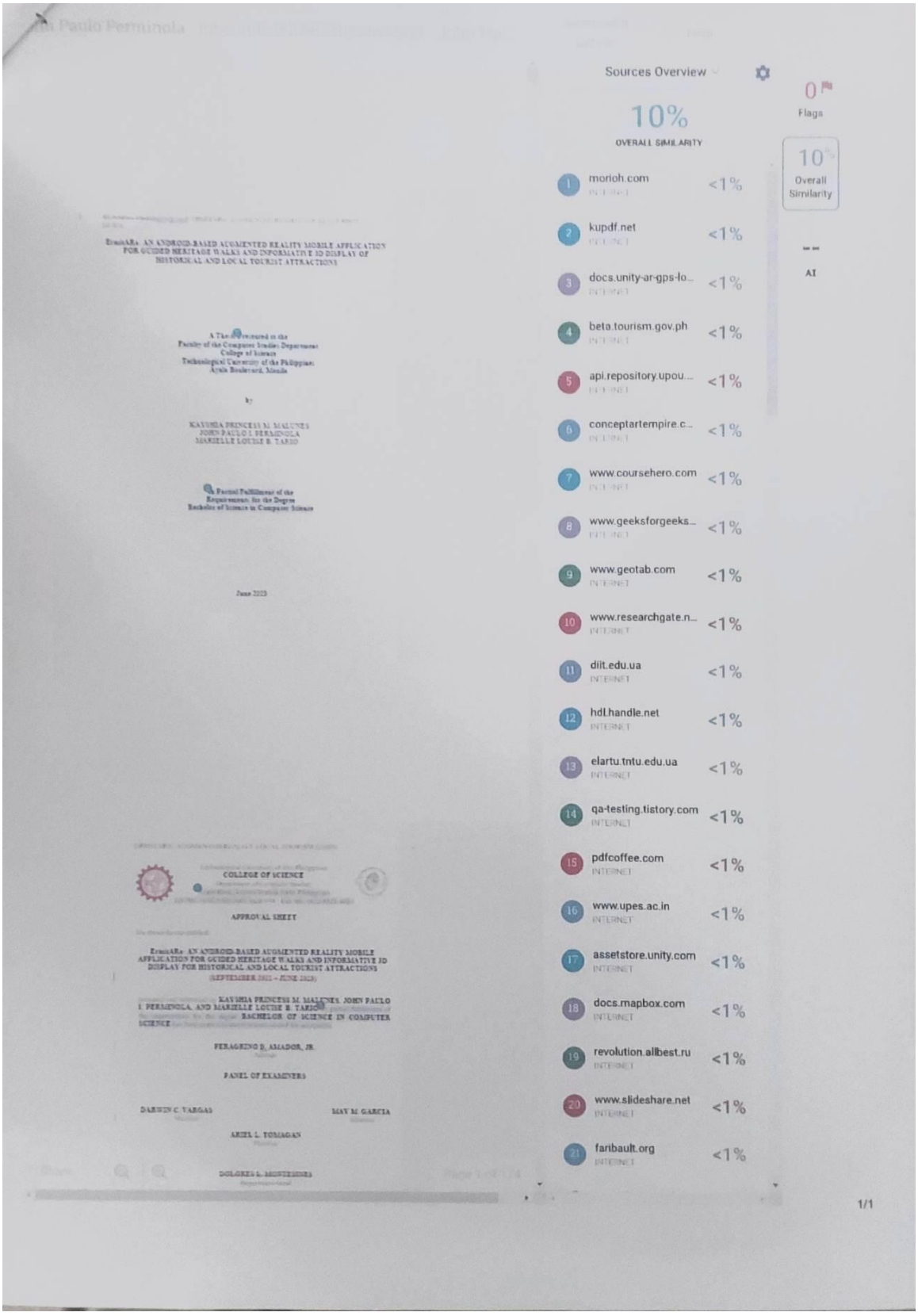
Certified correct by:

Assoc. Prof. FRANCISCO D. ESPONILLA II, Ed.D.
Director, University Research
and Development Services

Transaction ID	URD-TCERT-ELGB-10032022
Signature	

Appendix H

CERTIFICATE OF SIMILARITY INDEX USING TURNITIN



Appendix I

EVALUATION OF THE APPLICATION WITH THE TOURISM OFFICE OF THE CITY OF MANILA'S LOCAL GOVERNMENT UNIT

Appendix J

CURRICULUM VITAE

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