**MANILA AR.VENTURE: AN AUGMENTED REALITY-BASED
TRAVEL GUIDE AND DIRECTORY APPLICATION
FOR EXPLORING MANILA CITY**

**A Thesis Presented to the
Faculty of the Computer Studies Department
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**In Partial Fulfillment of the
Requirements for the Degree
Bachelor of Science in Computer Science**

by

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This thesis hereto entitled:

MANILA AR.VENTURE: AN AUGMENTED REALITY-BASED TRAVEL GUIDE AND DIRECTORY APPLICATION FOR EXPLORING MANILA CITY

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ABSTRACT

This study presents "Manila AR.Venture," an Android-based augmented reality (AR) mobile application designed to enhance the exploration and navigation of Manila City. Designed as a comprehensive travel guide and directory, the application seamlessly integrates AR technology to offer an immersive and informative experience for exploring the city. Its primary aim of enhancing travel exploration is achieved through several key features: (a) an AR map displaying relevant 3D landmarks upon plane detection, (b) a user-friendly filter system to categorize landmarks, (c) interactive 3D landmark models with detailed descriptions, and (d) an outlining AR feature for enhanced navigation, implemented with an A* pathfinding algorithm to determine optimal routes within the city. The development of this system utilized Unity 3D, Blender, Mapbox API, and Unity AR+GPS asset. A comprehensive evaluation, involving 30 respondents from diverse backgrounds—15 IT professionals, 7 students, 5 Manila residents, and 3 tourists—was conducted to assess the application's acceptability based on ISO 25010 criteria. These criteria encompassed functional suitability, usability, portability, and performance efficiency. The evaluation results indicated an overall frequency score of 3.41, denoting a descriptive rating of **Highly Acceptable**.

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Chapter 1

THE PROBLEM AND ITS SETTINGS

Introduction

The advent of technology has indeed brought about a paradigm shift in the way we explore and understand our environment. Augmented Reality (AR) is one technological breakthrough that enhances our perception and interaction with our surroundings by overlaying digital information onto the real world. This paper aimed to introduce "Manila AR.Venture," an AR-based travel guide and directory application that revolutionize the way people explore Manila City.

This research is significant as it holds the potential to transform the travel and tourism industry. Manila AR.Venture can significantly enhance the way tourists and residents explore cities by providing an immersive, engaging, and educational experience. While AR holds immense potential for the tourism industry, past attempts to incorporate this technology into travel guides have been few and inadequate.

Our research aimed to bridge this gap by developing an AR-based application specifically designed for Manila City. The objectives of this study are to develop a user-friendly interface, create an accurate augmented reality system that projects information into the real world, and evaluate the effectiveness of Manila AR.Venture as a travel guide.

The first section of the research provides a comprehensive overview of augmented reality technology and its applications in travel. It then delves into a review of previous studies on augmented reality-based travel guides, highlighting their limitations and suggesting areas for improvement.

For instance, a study aimed to develop an Android-based Augmented Reality Tourists Guide Application to enable tourists to experience a visual presentation of tourist destinations in the province of Surigao del Sur, particularly in the BLOM (Barobo, Lianga, Otieza/San Agustin, Marihatag) areas (Pitos, 2019). Another research proposed an interactive guide system combined with augmented reality technology to provide tourism services for tourists in tourist attractions based on geographic locations (Zhuang et al., 2022).

The paper then positions Manila AR.Venture within this context, detailing the specific research problem it aims to address. It presents a clear problem statement: "How can we leverage AR technology to enhance urban exploration in Manila City?"

The paper is structured as follows: Chapter 2 provides a literature review on AR technology and its applications in tourism. Chapter 3 details the methodology used in developing Manila AR.Venture. Chapter 4 presents the results of the application's testing phase. Finally, Chapter 5 discusses the implications of the findings and provides recommendations for future research.

Background of the Study

The traditional means of tourism marketing mostly rely on mass media (print media, television, etc.), and it has been long proven to be very effective (Rivera et al., 2016). However, according to Suselo et al. (2016), previous research has shown that travel directories were effective in optimizing the travel experience of tourists. These directories help the tourists easily and efficiently navigate through numerous selections based on their personal interests, without needing to ask for firsthand information. While travel directories are not a replacement to tourism marketing, they are now becoming an essential complement.

Groth & Halswanter (2016) highlights in their study how the population is having a "tremendous shift in the pattern of Internet usage demands" (p. 2) by turning to mobile phones as the main access to the internet. As a result, the industry also makes efforts to have their information and services available on mobile phones, through mobile-based websites and mobile applications. This adaptation to the trend is essential to consistently cater to the needs of the consumers. The tourism sector keeps up with this trend by gradually integrating their services digitally, through mobile services and personal digital assistants (PDAs) (Afolalu et al., 2016). Smart mobile applications provide interactive solutions to tourists, improving their whole experience not only for planning, but also during their actual exploration. Additionally, these applications are not only beneficial to the tourists, but also a platform for small and medium-sized enterprises (SMEs) to promote their products and services through business directory systems (Suselo et al., 2016).

Recent advancements in technology include Augmented Reality (AR), a type of technology characterized by superimposition of 3D objects on a surface in a digital display (e.g., smartphone screen). AR is currently being utilized for numerous different purposes including medicine, assembly and repair, entertainment, data visualization, tourism, architecture and construction, education, and military applications (Manuri & Sanna, 2016). With the continuous gain of popularity of mobile applications, AR is gradually becoming available to the users, especially in mobile games. In tourism, AR is an excellent addition for marketing, educational, and entertainment purposes (İlhan & Çeltek, 2016). Using smartphones, the travel sites' surroundings, especially in museums and historical heritages, can be implemented with AR, featuring 3D objects and historical information, allowing for a more immersive experience. Navigational directions within the site can also be applied with AR for clearer instruction. Brochures, magazine covers, posters, etc. can be also integrated with AR to catch tourists' attention. The possibilities with this rising technology are countless, as well as the opportunities it will give to industry.

Objectives of the Study

The general objective of this study is to develop an Augmented Reality (AR) system that serves as a comprehensive travel guide and directory, leveraging AR technology to significantly enhance the travel experience for tourists exploring Manila City.

Specifically, this study is designed to:

1. Design an Android mobile application named "Manila AR.Venture" with the following features:

    a. Implement an augmented reality (AR) map of Manila City that appears upon plane detection showcasing relevant 3D landmarks of various locations.

    b. Develop a user-friendly filter feature that allows users to categorize landmarks by type, such as sights, parks, churches and shops.

    c. Integrate AR technology to enable users to click on augmented 3D landmarks with each click displaying a description of the landmark.

    d. Implement Outlining Augmented Reality (AR) to provide an enhanced navigation process and experience.

2. Develop and implement an efficient pathfinding algorithm using A* to find the shortest route to a specified location within Manila City, enhancing navigation capabilities for users.

3. Evaluate each of the mobile application component's acceptability based on applicable ISO 25010 using the following criteria:

    a. Functional Suitability

    b. Usability

    c. Portability

    d. Performance Efficiency

Scope and Limitations

"Manila AR.Venture" is an Android mobile application that offers an immersive Augmented Reality (AR) experience for tourists visiting and exploring Manila City. It provides users with an AR map featuring interactive 3D models of iconic landmarks such as Quiapo Church, Intramuros, Rizal Park, Manila City Hall, and more, which was all designed using Blender. Users can filter destinations based on categories like sights, parks, churches, and shops, making it easy to locate specific points of interest. It also allows users to interact with these 3D models for enhanced navigation, enabling them to navigate from their current location to their chosen destinations.

The application is intended to rely on a plane detection to activate the AR map. This approach establishes a specific requirement for initiating the AR experience, thereby outlining a key limitation of the application. Users now only need to ensure they have access to a plane surface to engage with the augmented reality content effectively.

Moreover, Its Augmented Reality capabilities are contingent on Android devices equipped with ARCore services, commonly known as Google Play Services for AR. Optimal performance is achieved on devices that include supported Depth Sensors and OpenGL ES.

The evaluation of the application's level of acceptability and software quality, "Manila AR.Venture" involved the ISO 25010 criteria, gathering feedback from 30 respondents who engaged with the application's features via a survey. This approach ensures alignment with industry-standard quality metrics and offers insights into usability and overall acceptability.

Significance of the Study

The study titled "Manila AR.Venture: An Augmented Reality-based Travel Guide and Directory Application for Exploring Manila City" holds substantial significance in the following areas:

Tourists and Visitors: AR.Venture revolutionizes Manila exploration, providing a personalized and immersive experience. Real-time augmented information and interactive 3D models transform sightseeing into an engaging adventure, while filterable categories empower visitors to curate their perfect itinerary.

Manila Residents: Residents can rediscover their city through a new lens, navigating with ease and uncovering hidden treasures. AR.Venture enhances daily life by providing a convenient and engaging way to explore familiar surroundings with fresh insights.

Local Businesses and Economy: The application serves as a digital gateway for local enterprises, boosting visibility and attracting a wider customer base. By promoting local shops, restaurants, and services, the app fosters economic growth and supports job creation within the city.

In essence, this study could have far-reaching implications, impacting not just the tourism sector but also local businesses, -cultural preservation efforts, technological advancements, and everyday life in Manila City.

Chapter 2

REVIEW OF RELATED STUDIES AND LITERATURE

This chapter provides a comprehensive examination of existing scholarly works and research relevant to the subject matter, offering insights into the current state of knowledge in the field, and establishing a framework that informs and guides the subsequent investigation.

Tourism

Travel exploration is important since it not only broadens our horizons but also promotes personal development, cultural comprehension, and self-discovery. It helps people to move beyond their comfort zones, immerse themselves in new situations, and connect with others from different backgrounds. People can obtain a better understanding of the world's natural beauty, historical sites, and cultural legacy through travel, eventually fostering global citizenship and connection. One of the most famous travel statements: "Travel is fatal to prejudice, bigotry, and narrow-mindedness, and many of our people need it sorely on these accounts. Broad, wholesome, charitable views of men and things cannot be acquired by vegetating in one little corner of the earth all one's lifetime" (Twain, n.d.). This quotation highlights the potential of travel to question preconceived assumptions and expand our brains to new views, eliminating preconceptions that might come from restricted experiences.

Furthermore, the importance of trip exploration is demonstrated in various research that emphasize its good impacts on human growth and well-being. Travel has been demonstrated in studies to improve creativity, self-confidence, stress reduction, and

general life happiness (Chen and Petrick, 2023). Individuals can acquire a larger perspective, become more adaptive, and grow empathy for others by exposing themselves to other cultures, customs, and settings. Also investigated the difficulties of tourist destination branding and emphasized the importance of trip exploration in widening viewpoints and creating cultural comprehension (Pike, 2005).

Travelers may have a better knowledge of foreign cultures and promote global citizenship by immersing themselves in unfamiliar settings and engaging with people from diverse backgrounds. Moreover, in The Tourist: A New Theory of the Leisure Class (2013), MacCannell highlights the transforming impact of travel in questioning preexisting ideas and eradicating narrow- mindedness. Travel, according to MacCannell, helps people to broaden their viewpoints and build a more open worldview.

Tourism Directory

Tourism directories play a significant role in the tourism industry. They serve as a comprehensive resource for tourists, providing information about various tourist destinations, accommodations, travel agencies, and other related services. A tourism directory plays a significant role in the tourism industry for several reasons:

Information Accessibility: A tourism directory offers detailed information about a range of tourism-related services in a particular region or nation, including lodging, dining options, travel agencies, and attractions (Stainton, 2023). Travelers now find it simpler to locate all the information they want in one location.

Easy Planning: Travelers can arrange their vacations more effectively when they have access to all the information they need. People may use the directory's information to choose where to go, what to do, where to stay, and where to eat (Stainton, 2023).

Promotion of Local companies: Listings of local companies are frequently found in tourism directories, which can assist these firms in expanding their customer base. Asserts that by bringing in additional clients, this can strengthen regional economies (Carizal, 2023).

Cultural Exchange: Tourism directories may promote a sense of cultural exchange by giving information on regional cultures, traditions, and areas of interest. Travelers' experiences can be improved by learning about the history and culture of the destination (Stainton, 2023).

Sustainable Tourism: A few travel guides also include details on environmentally friendly activities and sustainable travel choices. This may persuade travelers to make more ecologically friendly decisions when they are traveling (Stainton, 2023).

In conclusion, a tourism directory is an important tool that benefits both tourists and the local economy. It promotes efficient trip planning, supports local businesses, fosters cultural exchange, and encourages sustainable tourism practices.

Innovative ICT in tourism

ICTs, or information and communication technologies, have had a major impact on the tourist sector. They have presented a wide variety of fresh opportunities for the expansion of tourism (Lee et al., 2021). ICTs have a variety of effects on the growth of

tourism, including Internet use, secure Internet servers, mobile cellular subscriptions, high-technology exports, communications, computers, and fixed broadband subscriptions (Lee et al., 2021). For example, there are more favorable effects on passenger arrivals when there are more fixed broadband subscriptions, secure Internet servers, and mobile cellular subscribers (Lee et al., 2021).

But there can be serious problems when there aren't enough technological employment or innovative tourism opportunities. There is a severe and ongoing labor shortage in the tourist sector right now. The labor supply and demand gap persist in 2020 after 62 million travel and tourism jobs were lost. Currently, unemployment rates for tourist occupations in the United States are 7%, but in the European Union they are anticipated to be 11% (Binggeli et al., 2023). Employees in the tourist business have been leaving, especially those in customer-facing positions, and there is no indication that this trend will stop. Staff shortages may cause problems for hotels, restaurants, cruise ships, airports, and airlines in terms of operations, finances, and reputation. If unaddressed, these shortages may constrain the industry's growth trajectory.

Hoteliers now find it simpler to adjust to the new reality and generate employment in the business thanks to the incorporation of new technologies (Challenges and Opportunities for the Tourism Sector in 2021 - ATREVIA, 2023). As a result, a lack of technical innovation may make these issues worse and make it more difficult for the sector to develop and adapt. It's critical to realize that technology is a tool, not a goal, and that travel is a personal experience that is frequently shared both online and off (IE Insights,

2019). To supplement current staffing needs or address current pain points, the sector must

enhance its procedures, offerings, and ability to recruit people.

Historical Sites

Historical sites are important tourist destinations that attract visitors from across the

world as well as those from inside the country (Heritage Tourism | Advisory Council on

Historic Preservation, n.d.-b). In addition to being significant sources of inspiration and

identity for communities, they may give local government organizations extra funding

through carefully thought-out initiatives and programs (Del Rosario, 2023).

The top ten historical sites in Batangas Province were the subject of a survey that

revealed their rich cultural heritage, high regard, and status as unique travel destinations.

The study also showed that the following characteristics have a major impact on visitor

attendance: a variety of museums and galleries, easy-to-use local transportation, nice and

welcoming locals, safety and security, and visual attractiveness (Mindanao et al., 2021).

Another study on visitors to Sagada, a cultural destination in the Philippines,

discovered that travelers are more likely to visit if they are driven by push factors like

adventure, escape from daily life, and prestige as well as pull factors like accessibility,

attractions, culture and history, and infrastructure. The analysis also found that, of the four

main effects on tourists—environmental, sociocultural, economic, and mass media—

economic impact has the greatest influence (Agnes and Gamueda, 2019).

These studies emphasize the value of historical places in tourism, emphasizing their

capacity to strengthen local economies, protect cultural heritage, and offer visitors

worthwhile experiences. To further increase these historical sites' contribution to the tourist sector, it is imperative that preservation and promotion activities be maintained.

Procedures for Designating for Historical Site Preservation

In the Philippines, there are many procedures involved in designating a place for historical preservation. A comprehensive Procedure and Work Instruction Manual (PAWIM) published by the National Museum of the Philippines describes in detail the steps involved in documenting and registering cultural property, as well as in declaring or delisting National Cultural Treasures and Important Cultural Properties (Procedure and work instruction manual (PAWIM), n.d.).

The National Cultural Heritage Act of 2009, also known as Republic Act No. 10066, has also been put into effect by the National Commission for Culture and the Arts (NCCA) (NCCA IMPLEMENTING RULES AND REGULATIONS OF Republic Act No. 10066 - AN ACT PROVIDING FOR THE PROTECTION AND CONSERVATION OF THE NATIONAL CULTURAL HERITAGE, STRENGTHENING THE NATIONAL COMMISSION FOR CULTURE AND THE ARTS (NCAA) AND ITS AFFILIATED CULTURAL AGENCIES, AND FOR OTHER PURPOSES - Supreme Court E-Library, n.d.). The NCCA and its associated cultural agencies are strengthened by this legislation, which provides for the preservation and protection of the nation's cultural legacy.

An analysis of the experiences of museum curators and the elements that go into successful conservation, for instance, is covered in a study on the preservation of cultural and historical heritage in the Province of Laguna, Philippines (Conservation of Cultural and Historical Heritage in the Province of Laguna, n.d.). Different research examines the ways

in which the colonial past of the Philippines shaped the nation's methods for preserving its cultural legacy (Colonizing the Filipino Palate, n.d.).

Technological Innovations in Historical Site Preservation

Governments, institutions, and technology must work together to preserve historical legacy, which is a crucial duty (Telefónica, 2023). Technological developments have made it possible for tangible and intangible cultural heritage to be preserved, promoted, and disseminated more easily (Diaz-Mendoza et al., 2023).

Virtual Reality (VR), which enables the production of interactive digital models of buildings, monuments, and other cultural artifacts, is one of the most inventive technical advancements in this subject. When terrorists attack cultural landmarks or when hostilities break out, this technology is very crucial (Telefónica, 2023).

The most popular technologies for conserving cultural heritage, aside from virtual reality (VR), are said to be 3D digital technology and augmented reality (AR). These technologies have been used to preserve cultural and intangible heritage digitally, promote historic locations, educate about a nation's rich cultural diversity, and spread regionally distinctive traditional symbols (Diaz-Mendoza et al., 2023).

Interdisciplinary case studies have also demonstrated how different fields, including archaeology, materials science, climate science, chemistry, engineering, computer science, and many more, can assist in reconstructing historical events, keeping an eye on the state of monuments and artwork, restoring and conserving them, and

facilitating public access to cultural heritage ("Science and Technology for Cultural

Heritage: A Nature Italy Event," 2021).

Manila City and its Landmarks

The Philippines' capital city, Manila, is a historical and culturally significant place.

From its beginnings as a pre-colonial trade station to its current position as a thriving

metropolis, the city has seen the rise and fall of empires (Salita, 2023). The city's famous

past and dynamic present are both reflected in its landmarks. They each bear the mark of a

distinct era in the city's history and serve as mute witnesses to the changes the city has

undergone throughout the millennia (Mega-World, 2022). These landmarks are more than

simply buildings. They are the essence of the city, telling the story of Manila by virtue of

their mere being. These serve as tangible representations of the city's collective memory

and serve as a constant reminder of the city's adaptability and ongoing development.

Because of this, a great deal of research and writing has been done on them with the goal

of revealing the secrets that these sites conceal. These studies greatly advance our

knowledge of Manila as a city and a community by offering insightful perspectives on the

city's history, people, and culture. They are valuable tools for anybody interested in

learning more about the spirit and essence of this intriguing city.

Quiapo Church

Quiapo Church, frequently referred to as the Saint John the Baptist Parish or the

Minor Basilica of the Black Nazarene, is a prominent landmark in Manila, Philippines

(Trip.com, n.d.). The Black Nazarene, a life-size figure of Christ that is said to perform

miracles, is kept there. Because of this, followers now frequently visit the church to complete the novena every Friday.

The church's designation as a national shrine served to emphasize its significance for tourists even more (Tobias, 2023). In addition to recognizing the church's function as a hub of religion and a destination for pilgrims, this designation increases the likelihood that the Quiapo area will be designated as a national historic zone. With such a designation, the area would get more funding and resources from the federal government for infrastructure, tourist development, and the preservation of historic buildings.

Intramuros

Known as the "Walled City," Intramuros is a historic neighborhood in Manila, Philippines, that presents Manila during the Spanish era. Because of its rich history and culture, it is one of the most popular historical tourist destinations in the Philippines. The government brought Intramuros back to its current condition in the 1980s, and in 2020 it was acknowledged globally as Asia's Top Tourist Destination (Rocamora, 2020).

Numerous historical landmarks and tourist destinations, including as Fort Santiago, Manila Cathedral, San Agustin Church, and Museo de Intramuros, can be found in the region. Visitors may get a taste of the nation's colonial past through the American Commonwealth at these places.

To sum up, Intramuros is essential to the Philippines' tourism industry. It is an essential travel destination for both domestic and foreign travelers because of its historical relevance as well as its cultural and architectural worth.

Manila City Hall

Manila City Hall is a notable landmark in the Philippines' capital city, situated at

the heart of a popular tourist destination. Renowned for its distinctive architectural style,

the Antonio Toledo-designed structure houses many government agencies (Guia, 2012).

The National Museum of the Philippines (NMP) has designated Manila City Hall as an

"Important Cultural Property" because of its significance to both culture and history (Ong,

2018).

Metropolitan Theater

One of the most important landmarks in the Philippines' capital city is the Manila

Metropolitan Theater, or MET (Planet of Hotels Editorial Office, 2013). The MET was

created by Filipino architect Juan M. Arellano and is among the country's few remaining

examples of Art Deco architecture. Since its December 10, 1931, opening, it has been a

vital part of Manila's cultural scene (Grana, 2021). The biggest events in the nation have

taken place in the theater, which has hosted the elite of Philippine politics, entertainment,

and society. The theater sustained significant damage during World War II, but it was

painstakingly rebuilt and is today a bright reminder of Manila's opulent past (Guia, 2021).

National Museum

The National Museum of the Philippines is an educational, scientific, and cultural

organization under government management that collects, records, conserves, displays,

and encourages public and scholarly study of artwork, specimens, and historical and

cultural relics. Operating out of the National Museum Complex in Manila, it is responsible

for managing the National Museum of Natural History, National Museum of Anthropology, and National Museum of Fine Arts. Additionally, the organization runs branch museums around the nation (National Museum, n.d). Leading modern painters, sculptors, and printmakers as well as 19th-century Filipino masters, National Artists, and other artists are on display in 29 galleries and hallway shows at the National Museum of Fine Arts (Nationa Museum of Fine Arts, n.d). Permanent research projects are conducted by the museum in the following areas: art history, ethnology, biodiversity, geological history, human origins, prehistoric and historical archaeology, marine and undersea cultural assets, and moveable and immovable cultural goods (National Museum, n.d).

   Rizal Monument

   The Rizal Monument, located in Manila City, is a monument for the Philippines' unofficial national hero, Dr. Jose P. Rizal. The 14-meter-high structure, made of unpolished granite and bronze, features Rizal in an overcoat holding his novels, symbolizing his role in the fight for Philippine Independence. The obelisk represents Rizal's masonic background, and the three gold-plated stars signify Luzon, Visayas, and Mindanao. It was designed by Dr. Richard Kissling, a Swiss sculptor, and was also dubbed as "Motto Stella," meaning "guiding star." The monument was a commemoration of Rizal's execution, to which the monument is located. Rizal's remains were interred beneath the monument in 1912, and on December 30, 1913, during Rizal's 17th death anniversary, Luneta Park was officially renamed "Rizal Park" in his honor. (National Parks Development Committee, n.d.)

   Metropolitan Theater

The Metropolitan Theater, known as the MET, reopened its doors on December 10, exactly 90 years after its inauguration in 1931. The restoration was driven by the goal of reclaiming its status as the "People's Theater" and a thriving space for Philippine arts and culture. Originally designed by architect Juan Arellano, the MET, now under the National Commission for Culture and the Arts (NCCA), aims to showcase a diverse range of Filipino works, from plays and musicals to indigenous performance arts, embodying its role as a symbol for arts and culture in the Philippines. The MET's reopening aligns with its mission to be a venue for both established and emerging artists, fostering the growth and preservation of local art forms. (Gonzales, 2022)

Malacañang Palace

Malacañang Palace, the official residence and workplace of the Philippine president, is an elegant Spanish colonial-style villa situated in Manila's San Miguel neighborhood along the northern bank of the Pasig River. Built in 1750 as a private summerhouse for Spanish aristocrat Don Luis Rocha, the state acquired it in 1825. Following the destruction of the official residence of the Spanish governor-general in an 1863 earthquake, Malacañang became the seat of government. It continued in this role when the Philippines came under U.S. control in 1898 and subsequently became the official residence for Filipino presidents after gaining independence in the 1940s. (Kay, 2023)

Manila Hotel

The Manila Hotel, renowned for its rich history, refined ambiance, and exceptional service, stands as the preferred choice for a discerning clientele. Following extensive renovations in 2008 leading up to its centennial celebration in October 2012, the hotel's

rooms were fully refurbished, now offering modern amenities while exuding elegance through authentic Philippine interior design. Notably, the revamped Café Ilang-Ilang introduces a three-period meal buffet restaurant with nine live cooking stations, complemented by a renovated Pool and Garden area. The hotel also features a newly opened spa and health club by the bay, equipped with a state-of-the-art gym, sauna, steam room, and Jacuzzi. (The Manila Hotel, 2021)

China Town

Binondo, commonly known as Manila Chinatown, stands out as a top destination for food enthusiasts and cultural explorers alike. Recognized as the world's oldest Chinatown, it offers a unique blend of gastronomic delights and rich cultural heritage. The influence of Far Eastern culture on Filipino life is vividly evident throughout this historic district, providing a culturally immersive experience. Among its notable features, Ongpin Street, the renowned thoroughfare, serves as a bustling hub where vendors, offering a diverse range of goods from fresh produce to lucky charms, line the sidewalks and alleyways. (De Leon, 2018)

Manila Ocean Park

Manila Ocean Park, situated near the Quirino Grandstand in Ermita, Manila, stands out as one of the world's premier public aquariums, conveniently located just nine kilometers from Ninoy Aquino International Airport. Boasting a diverse collection of marine life, including birds, fish, penguins, and sharks, its main attraction is the Oceanarium, featuring 14,000 aquatic creatures from 277 Southeast Asian breeds. The highlight is an 82-foot glass tunnel providing a unique underwater view. The park, opened

in 2008 by China Oceanis Philippines Incorporated, also houses educational spaces, function rooms, and unique attractions like the Birds of Prey Kingdom and the World of Creepy Crawlies. Constructed by E.R. Hitosis and Associates, the park showcases an elaborate structure built near Manila Bay, drawing global recognition as a world-class seawater theme park. (Ergino, 2022).

*Luneta Lagoo*n

Known by several names, including Rizal Park and Luneta Park, Luneta Lagoon is a historic urban park situated in the center of Manila. It is also known for its expansive lawns, gardens, ponds, and important monuments, which include the one honoring Dr. Jose Rizal, the national hero. In addition to holding a variety of events and offering a green area for both locals and visitors, the park functions as the social, cultural, and political center of the city (2HotTravellers, n.d.).

*Arroceros Forest Par*k

Known as the "last lung" of Manila, Aroceros Forest Park is a 2.2-hectare urban forest that offers a green haven in the middle of the crowded metropolis. It is an important biological area for the town and is home to a variety of trees, plants, and birds. There is constant research and worry about the park's survival as well as the issues it meets, such vandalism and informal settlements (Membrebe Jr., Ancheta, Santos, Valeroso, & Batac, 2019).

Quirino Grandstand

Recognized as a significant landmark in Manila, the Quirino Grandstand is where the Philippines' presidents take their oath of office. Significant incidents have also occurred there, such the Manila hostage crisis, which brought attention to problems with the nation's crisis management and law enforcement capabilities (Avila, 2010).

Fort Santiago

Fort Santiago is a medieval fortress in the center of Intramuros, Manila. It was founded in 1571 by Spanish conquest Miguel López de Legazpi and has since served as a reminder of the Philippines' rich heritage. During the Spanish era, the fort was used as a military fortress, jail, and depository for colonial artifacts. It is well-known as the location where Dr. José Rizal, the Philippine national hero, was held before his execution. The edifice has seen several stages of colonial control, from Spanish to British, and after American and Japanese soldiers, each leaving their mark on its construction and purpose. Today, Fort Santiago is a beloved national landmark, being the Filipino battle for independence and mourning the lives lost during World War II (Intramuros Administration, n.d.; Guide to the Philippines, n.d.).

Casa Manila

A museum found within the historic walls of Intramuros, Manila, is a replica of a 19th-century Binondo residence. Designed by architect J. Ramon L. Faustmann, it was constructed in the 1980s to highlight the opulent lifestyle of affluent Filipino families during the Spanish colonial period. The museum's façade is patterned after a house that once stood on Jaboneros Street in the Chinese district of Binondo in the 1850s. Casa Manila's interior decor, which includes painted walls, crystal chandeliers, carved traceries,

and gilded furniture, reflects the elegance and luxury of that era. The museum also features

the Piedra China or Chinese granite, which were once used as ballast in Chinese trading

junks. Casa Manila serves as a cultural gem that offers a glimpse into the past, providing

visitors with an immersive experience of the Philippines' colonial history (Intramuros

Administration, n.d.; Guide to the Philippines, n.d.).

Jones Bridge

Jones Bridge, a historic structure spanning the Pasig River in Manila, Philippines,

is named after William Atkinson Jones, the author of the Jones Law. Originally designed

by Filipino architect Juan M. Arellano in French Neoclassical style, the bridge was

completed in 1920. It replaced the Puente de España and connected the districts of Binondo

and Ermita. The bridge was destroyed during World War II and after rebuilt in 1946.

Recent restoration efforts have revitalized its architectural beauty, making it a symbol of

Manila's resilience and heritage (Esquire Philippines, 2019).

Paco Park

Paco Park in Manila, originally named Cementerio General de Dilao, was built

during the Spanish colonial period and served as the city's municipal cemetery. It is known

for its circular design and the historical significance of being the burial site of Philippine

national hero Dr. José Rizal after his execution in 1896. The park has since been

transformed into a national park, hosting various cultural events and providing a serene

green space in the city (Philippinature, 2023).

Manila Post Office

The Manila Central Post Office, a notable landmark in the Philippines, has been a pivotal part of the country's postal history since its establishment. Designed by famous architects Juan M. Arellano, Tomás Mapúa, and Ralph Doane, the neoclassical building was completed in 1928 and has since withstood the test of time, including severe damage during World War II and a significant fire in 2023. It is not only a functional hub for mail distribution but also a symbol of architectural beauty and historical resilience (Yu, 2024).

Katipunan Monument

The Katipunan Monument stands as a tribute to the revolutionary society that played a pivotal role in the Philippines' fight for independence from Spanish colonial rule. Founded on July 7, 1892, by Andres Bonifacio and his fellow patriots, the Katipunan, or Kataastaasan Kagalang-galang na Katipunan ng mga Anak ng Bayan (KKK), united Filipinos under a common cause to resist Spanish oppression. The monument itself, often associated with the image of Bonifacio wielding a bolo, symbolizes the courage and determination of the Filipino people during a critical period in their history (Kapampangan Media, 2023).

Palacio Grande, Intramuros

The Palacio del Gobernador, found in Manila's historic Intramuros area, is a reminder of the country's colonial history and progress toward democracy. Originally the palace of the Spanish governor-general, the structure was damaged by an earthquake in 1863 and rebuilt in its current form in 1976. Today, it has significant government agencies, such as the Intramuros Administration and the Commission on Elections, proving the

country's commitment to conserving its legacy and implementing democratic administration (An Asian Traveller, 2024).

University of Santo Tomas

The institution of Santo Tomas (UST), founded on April 28, 1611, is Asia's oldest institution and one of the world's largest Catholic universities, all found on one campus. UST was founded on the initiative of Bishop Miguel de Benavides, O.P., the third Archbishop of Manila, with the goal of preparing young men for the priesthood. Over the ages, UST has evolved into a complete institution with a diverse variety of undergraduate and graduate programs. It is known for its enormous contributions to the Philippines' history, culture, and education (University of Santo Tomas, n.d).

Manila Baywalk Dolomite Beach

The Manila Baywalk Dolomite Beach, also known as Dolomite Beach, is a popular manufactured beach in Manila Bay in the Philippines. It was developed as part of the Manila Bay Rehabilitation project using a method known as beach nourishment. The initiative, launched by the Department of Environment and Natural Resources (DENR), looks to improve coastal security and rehabilitate the coastal environment. The beach opened to the public in September 2020 and has since been subjected to both appreciation for its picturesque beauty and criticism for environmental issues (Manila Bay Coordinating Office, 2024).

999 Shopping Mall

The 999-shopping mall, found in the heart of Binondo, Manila, is a thriving hub for consumers looking for high-quality merchandise at reasonable costs. Established as a specialized mall, it has evolved into a shopping destination for both local consumers and resellers, particularly those seeking the flea market or "tiangge" experience. The first phase of the mall, a four-story structure with a gross floor space of 31,931 square meters, was finished in 2011. The second phase, finished a year later, included a seven-story structure with a gross floor space of 84,292 square meters, further confirming the mall's position as a leading player in the retail shopping market (Cosco Capital Inc., n.d).

168 Shopping Mall

The 168-shopping mall, a popular shopping destination in Manila's thriving Divisoria sector, is well-known for its diverse selection of low-cost items. Yeeloofa Development Corporation built the mall, which opened in September 2005, and the 168 Group of Companies manages it now. It has a unique cluster-based layout that divides stores into parts, making it simple for customers to discover what they're searching for. The mall has become a go-to location for bargain shoppers and entrepreneurs alike, selling things such as apparel, gadgets, toys, and home items (Yeeloofa Development Corporation, 2024).

Tutuban Center Mall

Tutuban Center, a historical and economic hub in Manila, was formerly the Tutuban Train Station, which opened in 1887 during Spanish colonial control. It functioned as an

important transportation connection, linking Manila to neighboring provinces. Tutuban Center, was constructed in 1993, is now a lively commercial complex in the Divisoria shopping district that includes retail buildings and a public transportation hub. The center keeps the tradition of the old rail station, which is now a designated national historical building, while running as a modern-day marketplace for a range of commodities (Philippine Brands, 2023).

SM Manila

SM City Manila, part of the renowned SM Supermalls complex, is a major shopping and entertainment destination in the heart of the Philippine capital. It opened on April 14, 2000, and was one of the first commercial malls to contribute to Manila's urban growth. The mall's strategic location near various educational institutions makes it a popular destination for both students and families. SM City Manila is an essential element of the city's modern lifestyle, offering a varied range of retail outlets, dining alternatives, and entertainment facilities (Philippine Brands, 2023).

Robinsons Place Manila

Robinsons Place Manila, Robinsons Land Corporation's main mall, is a top shopping destination in the historic city of Manila. It opened in 1980 and has since undergone multiple expansions to meet the rising demands of its broad customers. The mall is conveniently positioned next to the University of the Philippines Manila and the Philippine General Hospital, on the site of the former Ateneo de Manila Campus. It has nearly 500 businesses and services, providing a complete shopping experience that

includes retail shops, food outlets, and entertainment facilities (Robinsons Land Corporation, n.d.).

UN Square Mall

UN Square Mall in Manila is a global retail destination that embodies the city's vibrant energy via its modern architectural style and cultural aspects. It provides a diversified retail experience by combining high-end designer stores, local craftspeople, and gastronomic pleasures to appeal to a wide range of interests and preferences. The mall's dedication to sustainability is reflected in its green spaces, which offer a peaceful respite from the hectic surroundings. UN Square Mall is unity and diversity, combining technology and community interaction to go beyond the usual mall experience (Philippine Brands, 2023).

Avenida Shopping Mall

Avenida Shopping Mall, previously a thriving center of trade and social life in Manila, has a long history dating back to the early twentieth century. Avenida, known for its magnificent theaters and variety of local merchants, was the core of Manila's retail sector before the emergence of contemporary shopping malls. The mall included the area's first department store, the Good Earth Emporium, which is credited with pioneering the usage of escalators in the Philippines. Today, Avenida Shopping Mall is a reminder of the city's bustling history and a popular shopping destination for both locals and visitors (Spot.ph, 2018).

SM City San Lazaro

SM City San Lazaro, opened on September 15, 2005, is a vibrant retail and lifestyle hub in Manila, Philippines. Owned by SM Prime Holdings, it is strategically found near historic landmarks such as the University of Santo Tomas and the former San Lazaro Hippodrome. The mall's design features modern aesthetics with spacious interiors and a welcoming environment for shoppers. It offers a diverse range of retail options, including fashion, electronics, and home goods, catering to the tastes and preferences of a wide customer base (Philippine Brands, 2023).

Divisoria Market

Divisoria Market, found in the center of Manila, is well-known as a shopping destination that offers a wide choice of items at some of the city's lowest rates. Divisoria is known for its lively environment and dense crowds, and it attracts people from all occupations looking for discounts. The market's labyrinthine booths are a treasure trove for bargain seekers and wholesale purchasers, selling everything from textiles to toys, electronics, and kitchenware. The market's history extends back to the Spanish colonial period, being the Philippines' rich cultural tapestry and its transformation into a modern-day economic hub (Esquire Philippines, 2020).

Lucky Chinatown Mall

Lucky Chinatown Mall, found in the historic district of Binondo in Manila, is a modern shopping center that offers a unique blend of cultural heritage and contemporary retail experience. Opened on August 15, 2012, it was designed to be a heritage project that

promotes Binondo's tradition of commerce and tourism. The mall has been recognized for its contribution to the community, winning the Shopping Center of the Year award by the Philippine Retailers Association in 2015. It features a mix of international fashion brands, dining options, and entertainment facilities, including upscale movie theaters, making it a popular destination for both locals and visitors (Megaworld Corporation, 2012).

St. Thomas Square

St. Thomas Square, found in Manila's lively University Belt, is a commercial complex that highlights early modern Filipino architecture. It was built in the early 2000s and has a design that beautifully combines form and function, with sweeping curtain wall profiles and lively flashes of color that add to its modern appeal. St. Thomas Square serves as an iconic landmark within the bustling neighborhood, providing a dynamic venue for business and being the Philippines' developing architectural landscape (JOG + Associates, n.d).

San Agustin Church

The San Agustin Church in Manila is a historic architectural masterpiece and the oldest stone church in the Philippines. Completed in 1607, it has withstood various natural calamities and conflicts to serve as a symbol of the country's rich colonial history and religious devotion. The church's baroque architecture, beautiful carvings, and historical items make it a notable cultural and tourist destination. It is also a UNESCO World Heritage Site (Santos, J. P. C., 2012).

Binondo Church

Binondo Church, commonly known as the Minor Basilica of San Lorenzo Ruiz, is a historically significant site in Manila's Chinatown. Established by Dominican missionaries in 1596 to serve Chinese converts to Christianity, the church has been rebuilt multiple times owing to war and natural catastrophe damage. The existing Baroque-style structure, built in 1852, is a symbol of the Filipino Chinese community's faith and strength. It is a notable cultural landmark that reflects the rich history of Catholicism in the Philippines (Out of Town Blog, 2023).

San Sebastian Church

The San Sebastian Church, formally known as the Basílica Menor de San Sebastián, is a noteworthy edifice found in the Quiapo area of Manila. Completed in 1891, it is Asia's first all-steel church, and one of the few in the world, built to survive the country's regular earthquakes and fires. The Gothic Revival style of the church combines baroque and neo-Gothic features, drawing inspiration from Spain's Burgos Cathedral. It has been recognized as a Philippine Historical Landmark and a National Cultural Treasure, showing its significance to the nation's cultural history (Two Budget Travellers, 2024).

Artificial Intelligence and Its Applications

Generally, artificial intelligence (AI) is defined as a computer's ability to mimic the intelligence of humans, such as reasoning (Copeland, 2023). Despite its simplicity, the definition of AI has been long debated by computer scientists and concerned professionals. Questions such as how 'intelligence' is defined, what 'human capabilities' are, as well as

AI's purpose, affect how AI is defined. Elaine Rich (as cited in Ertel, 2018) produced a well-constructed definition of AI, stating that "Artificial Intelligence is the study of how to make computers do things at which, at moment, people are better." (p. 2). This definition addresses the previous issues in AI's definition and is said to still be accurate even until the year 2050 (Ertel, 2018).

During the 1950s, the term "artificial intelligence" was only viewed as a theory of machines demonstrating human intelligence (Bini, 2018, as cited in Helm et al., 2020). However, due to the rapid development of technology, AI has "transitioned from mere theory to tangible application on an unprecedented scale" (Introduction section), performing very powerful operations that exceed human abilities. Because of this, AI is being irreplaceably utilized in different sectors and industries for countless varying purposes (Helm et. al., 2020).

In the computing field, deep learning, a type of AI, is widely used in Natural Language Processing (NLP) for understanding, interpreting, and generating human language to perform useful tasks (Deng & Liu, 2018), which are seen in virtual assistants managing schedules and emails (Agrawal et al., 2017). AI algorithms are also used to create recommendation systems by analyzing user preferences and behavior to provide personalized recommendations (Batmaz et al., 2019), which are proven useful in e-Tourism platforms in providing travel recommendations (Borràs et al., 2014).

In the industry, AI can be seen in healthcare for medical imaging, pattern recognition, and data analysis to assist in diagnosing diseases, interpreting medical images, and predicting patient outcomes (Pesapane et al., 2018). In education, applications powered

by AI are available, including personalized learning platforms, intelligent tutoring systems, and automated grading systems (Chen et al., 2020).

Computer Vision

Another field of artificial intelligence, computer vision is a technology mainly used for object and pattern detection through cameras, "thus enabling the computers to see" (Britannica, 2023, para. 1). Recent innovations include the use of deep learning in computer vision to further enhance its ability and accuracy in object detection, motion tracking, action recognition, human pose estimation, and semantic segmentation (Voulodimos et al., 2018).

Computer vision is also a key component in augmented reality, specifically for object and scene recognition and tracking, and localization and mapping. This enables AR applications to superimpose virtual elements into real scenes with precision (Turk & Fragoso, 2015).

Augmented Reality

Microsoft (n.d.) defined augmented reality (AR) as "an enhanced, interactive version of a real-world environment achieved through digital visual elements, sounds, and other sensory stimuli via holographic technology" (para. 2), hence the term "augmented." Contrary to the common view, AR has the capacity to augment not only the sense of sight, but all human senses (Loijens, Brohm, & Domurath, 2017). This would mean that AR can also be used to provide aid to physiologically impaired people, allowing deaf people to

"see" conversations, for example. Thus, AR's objective is to give users a better and more convenient way of perceiving and interacting with the world (Carmigniani & Furht, 2011).

In the field of AR, there are numerous related, and possibly synonymous, terms we encounter. Some of which include virtual reality, mixed reality, telepresence, extended reality, etc. Researchers usually have different perspectives over these. Tokareva (2018; as cited in Milman, 2018) provided the following definitions: "Virtual reality (VR) immerses users in a fully artificial digital environment. Augmented reality (AR) overlays virtual objects on the real-world environment. Mixed reality (MR) not just overlays but anchors virtual objects to the real world" (para. 1). Tremosa (2023) also defined Extended Reality (ER) as the umbrella term for these kinds of technologies. From these definitions, we can say that MR is an extension of AR, while VR is a different concept. As Loijens et al. (2017) stated, "AR supplements reality, rather than completely replacing it."

There are three aspects to be considered when creating an augmented reality system as stated by Loijens et al. (2017): (1) the combination of real world and virtual world, (2) real-time interactivity, and (3) 3D registration. An AR system should possess these three characteristics for it to be called one. Moreover, an AR system should be composed of both hardware and software systems as listed below (Kipper & Rampolla, 2013):

Table 1

Hardware and Software Components of an AR System

Hardware	Software
● A computer / mobile device ● Monitor or display screen ● Camera ● Tracking and sensing systems ● Network infrastructure ● Marker	● Application or program running locally ● Web services ● Content server

According to Edwards-Stewart, Hoyt, and Reger (2016), there are two general types of AR. First is the Triggered AR, which operates on "triggers". Triggers are what initiates the actual augmentation and what the system bases on carrying out its features. Examples of triggers include markers (paper or object), GPS location, dynamic augmentation, and combinations of these. The second is the View-Based AR, which operates on real-world, non-referenced, objects.

AR in various sectors

Nowadays, AR is being used in numerous different fields, some of which include advertising, where 3D views of products are shown to the consumers; task support, aiding employees in assembly and maintenance; navigation, providing users real-time, 3D directions; and home and industrial uses, for convenient furniture and appliance scale representations.

AR is also applied in art, allowing for a more immersive and interactive experience of artworks; social networking, for an improved experience of social connections; education, where 3D elements are displayed for clearer visualization; and translation, allowing for real-time translated text superimposition (Kipper & Rampolla, 2013).

AR's role in Enhancing Travel Exploration

The rapid advancement of technology has revolutionized the travel and tourism industry, and Augmented Reality (AR) has emerged as a powerful tool for enhancing user experiences in this domain. AR creates enhanced user experiences and is widely recognised as an effective tool to enhance interaction with, and perception of the real-world environment (Tussyadiah, Jung, & Tom Dieck, 2018). With its ability to augment the perception of reality, AR has gained recognition as an effective medium to engage and interact with travelers, providing them with enhanced exploration opportunities and enriched travel experiences. One good example of this is when Kuoni Travel, a travel agency based in England, has teamed up with AR providers Aurasma to engage potential tourists' attention and increase sales by developing AR advertising and magazine content promoting their services and products (Hassan, Ekiz, & Dadwal, 2018). This collaboration demonstrates how AR can deliver personalized content and tailored experiences to tourists, catering to their specific needs and preferences.

Augmented Reality has proven so far to be a technology that can provide tourists, and citizens of course, with much more personalized content and services tailored to their needs. Specifically, AR tourist guides can display content upon request as tourists travel around the city, exploring the cityscape and the sites. One could say that mobile AR

applications allow users to explore the world by adding new layers to their reality, thus resulting in a new interactive and highly dynamic experience. Moreover, as these applications are on most (if not all) occasions accessed over mobile devices with GPS functionalities, tourists can gain additional benefits and navigate themselves interactively with the help of the direct annotations of the selected locations (Kounavis, Kasimati & Zamani, 2012).

Markerless AR

Unlike marker-based AR, which relies on physical markers to trigger the augmentation, markerless AR utilizes various localization techniques to understand and track the user's environment in real-time (Khan & Soroni, 2022). This allows users to place and interact with virtual objects directly within their actual surroundings. A subset of markerless AR, geolocation-based AR, leverages a user's location data to associate digital content with specific real-world locations. This enables users with AR-enabled smartphones to interact with augmented information tied to their physical environment (Khan & Soroni, 2022). The widespread availability of AR-capable smartphones, driven by platforms like ARKit and ARCore (Khan & Soroni, 2022), presents an opportunity to develop innovative AR applications like the one proposed in this thesis.

Developing markerless AR applications presents a unique challenge. While existing AR SDKs are primarily geared towards marker-based experiences, markerless AR necessitates establishing the relative position relationship between virtual objects and users through various localization technologies. This often requires developers to select a

specific technology and build their own framework to form the connection between virtual

objects and the real world (Cheng et al., 2017).

Integration of Artificial Intelligence in AR

Artificial intelligence is known to be an essential part of innovation, especially in

the computing field. Through deep learning algorithms, information processing and

interpretation becomes easier and more powerful, as seen in recent innovations in speech

recognition and computer vision (Deng & Yu, 2014). As such, AI can also be applied in

enhancing AR processes, allowing for better scene recognition and wider user preferences

(Sahu et al., 2021).

A* Algorithm

The A* algorithm, classified as a heuristic search algorithm, operates by navigating

a path through multiple nodes on a graphical plane to determine the lowest-cost route. The

A* algorithm is often used in mobile computing for NPC in games, or for mobile

computing of online games (Guo & Luo, 2018). Its primary objective is to identify the most

efficient path between two points on the graphical plane while considering the associated

costs.

In practical terms, the A* algorithm bears similarities to both the Dijkstra algorithm

and Breadth-First Search (BFS). Like Dijkstra's algorithm, A* is adept at finding the

shortest path. However, what sets A* apart is its incorporation of heuristic search, a

characteristic it shares with BFS which means that A* not only explores potential paths but

also incorporates heuristic information to prioritize routes that are likely to lead to the

optimal solution more efficiently. A study conducted by Mehta et al. (2019) provides an in-depth overview of the algorithms and procedures employed by Google Maps to facilitate user operations. The paper delineates the methodologies employed by Google Maps for tasks such as identifying the shortest path, determining one's position, geocoding, and other sophisticated functionalities. Notably, the study delves into the distinctions between the Dijkstra and A* algorithms, highlighting those A* shares similarities with Dijkstra's algorithm but incorporates a heuristic function for more efficient pathfinding. A* assigns higher priority to nodes deemed superior based on parameters such as time requirement and distance, contrasting with Dijkstra, which explores all nodes. Consequently, A* is positioned as a faster alternative to Dijkstra's algorithm, notwithstanding potentially higher memory requirements and operations per node, as it navigates significantly fewer nodes, resulting in overall efficiency gains.

Implementation of A* Algorithm

A* Algorithm is widely used in various domains for pathfinding and optimization problems (Ravikiran, 2023). Its ability to find efficient paths in complex environments makes it an invaluable tool for optimizing routes, planning evacuations, and enabling intelligent behavior in robotics, games, and AI. Some examples that demonstrate the versatility and wide-ranging applications of the A* algorithm in various real-world scenarios are as follows.

a. Route Optimization for Delivery Services: Delivery services like Amazon, FedEx, and UPS utilize the A* algorithm to optimize delivery routes, minimizing fuel consumption, delivery time, and overall costs. The algorithm considers factors

like road conditions, traffic patterns, and delivery locations to determine the most efficient route for their delivery personnel or vehicles.

b. Evacuation Planning in Emergencies: Safety agencies and emergency response teams employ the A* algorithm to plan evacuation routes during emergencies, such as natural disasters or building fires. The algorithm efficiently calculates the shortest and safest evacuation paths for large crowds of people, considering factors like obstacles, crowd density, and exit points.

c. Pathfinding in Robotics and Autonomous Vehicles: The A* algorithm is widely used in robotics and autonomous vehicles to navigate complex environments and find the shortest path between their current location and a desired destination. Self-driving cars, robotic vacuum cleaners, and even autonomous drones utilize the A* algorithm to navigate roads, obstacles, and complex environments effectively.

d. Resource Allocation in Network Optimization: Network providers and telecommunication companies employ the A* algorithm to optimize network traffic routing and resource allocation. The algorithm identifies the most efficient paths for data packets to travel across the network, minimizing latency, congestion, and overall network load.

e. Planning in Video Games and Artificial Intelligence: The A* algorithm is a common tool in game development for creating realistic and intelligent pathfinding behavior for non-player characters (NPCs) in video games. It also plays a crucial role in artificial intelligence (AI) research, enabling AI agents to navigate complex environments and make optimal decisions in real-time.

Mobile Application

In the contemporary era of information and communication systems, the widespread use of computers and computer applications has become a common practice. As individuals increasingly rely on these technologies for various tasks, a notable shift has also occurred with the emergence of mobile applications. According to Islam and Mazumder (2010), mobile applications are running on a small hand hold mobile device which is moveable, easy to use and accessible from anywhere and any place. These factors have driven the widespread adoption of mobile applications, making them indispensable tools for communication, internet browsing, file management, document creation and handling, entertainment, and more. A study conducted by Habermann et al. (2016) investigated the usability and user experience of a mobile app for public transport, highlighting the growing significance of mobile applications in the transportation sector. The rapid advancement of smart devices and applications in this domain has unlocked a wealth of opportunities for innovative mobility services, enabling the personalization of travel experiences for individual users.

Augmented Reality Mobile Application

Augmented reality (AR) has witnessed significant advancements in recent years, marked by the development of specialized techniques and hardware devices. Early AR devices were cumbersome and limited in capabilities, while modern AR devices are sleek, powerful, and offer a wide range of applications. A pivotal turning point in its progress occurred with the widespread adoption of smart mobile phones, facilitating the mass proliferation of augmented reality applications (Prochazka et al., 2011).

In a recent study conducted by Coskun and Koc (2021), the impact of Augmented

Reality (AR) and mobile application-supported instruction on students' academic

achievement, attitude towards astronomy, anxiety, and motivation in seventh-grade

Science lessons focusing on "Solar System and Beyond/Earth and Universe" units was

explored. Utilizing a pre-test-post-test control group quasi-experimental design, the study

revealed that the integration of AR and mobile applications positively influenced academic

success. Interestingly, this instructional approach showed no significant effects on anxiety

and motivation towards the lessons. Furthermore, the study indicated that the introduction

of AR did not adversely affect students' attitude towards the content, as assessed by the

methods recommended by the current program. This research underscores the potential

benefits of incorporating AR mobile applications in educational settings, particularly in

enhancing academic achievement.

Compatibility Testing of Mobile Application

Mobile application testing stands as a crucial element in the software development

life cycle, ensuring a seamless user experience and consistent functionality across the

diverse spectrum of mobile devices. Given the variations in hardware specifications–

screen sizes, and operating systems, comprehensive testing is imperative. From the study

of Ali and Arif (2019), they stated that mobile application needs a different methodology

for assuring their quality, similarly these also need an efficient testing approach to develop

high quality mobile applications. Thus, compatibility testing of mobile application plays a

pivotal role in pinpointing and resolving issues related to usability, interface design, and

overall functionality. Beyond that, testing addresses security vulnerabilities, safeguards

data integrity, and ensures compliance with industry regulations. By evaluating the application's performance under varied network conditions, it contributes to optimized speed, responsiveness, and overall efficiency.

Global Positioning System

GPS, or Global Positioning System, is a satellite-based navigation system that enables precise determination of geographical location and provides accurate positioning information anywhere on Earth. It consists of a network of orbiting satellites that transmit signals to GPS receivers, which then use the signals to calculate the receiver's exact location, velocity, and time information. Developed and maintained by the United States Department of Defense, GPS has many applications; it has its usefulness in military, weather conditions, vehicle location, farms, mapping, and many other areas (Abulude, et al., 2015).

Increasing commercial use of the Global Positioning System will soon make it possible to locate anything, anywhere, anytime. The Global Positioning System can provide extremely accurate location information for mobile objects and people which is far superior to earlier tracking techniques. Today, GPS has a wide range of other applications including tracking package delivery, mobile commerce, emergency response, exploration, surveying, law enforcement, recreation, wildlife tracking, search and rescue, roadside assistance, stolen vehicle recovery, satellite data processing, and resource management (Bajaj et al., 2002). With its widespread integration into various sectors, GPS has become an indispensable tool, influencing not only navigation and location services but also

contributing significantly to fields such as scientific research, public safety, and efficient

resource utilization.

GPS Process in Mobile Applications

The recent developments in mobile positioning technologies and the increasing

demands of ubiquitous computing have significantly contributed to sophisticated

positioning applications and services. Position information, a core element in human-

centered activities, becomes particularly relevant in the context of mobile applications,

where it serves as a fundamental input for visualizing complex environments effectively.

The emergence of smartphones has played a pivotal role in accelerating the development

of cutting-edge positioning-based systems (Ramtohul & Khedo, 2020). Smartphones,

characterized by enhanced processing capabilities, ample memory, and powerful battery

performance, have become integral components for GPS processes in mobile applications.

These devices leverage the Global Positioning System (GPS) to provide accurate and real-

time location information, enabling functionalities such as localization, tracking, and

navigation. As a result, the synergy between advanced mobile technologies and GPS

processes has paved the way for an array of innovative and user-centric applications in

various domains. In a study conducted by Komal et al. (2012), they developed a set of

applications, including Place Marking, Shortest Path Strategy, and Weather Predictions for

the next four days. These applications operate in coordination with Google Maps in a live

environment, effectively tracking user-defined locations and points of interest for future

reference. Importantly, the applications seamlessly integrate with the GPS process,

utilizing Google Maps to determine the shortest path and provide weather predictions in

both degrees Celsius and Fahrenheit. This research sheds light on the evolving intersection of advanced mobile technologies and GPS functionalities, showcasing innovative applications that enhance user experience and address real-world needs.

Location-based services

A Location-Based Service (LBS) is a specialized software service designed for mobile device applications, necessitating access to the geographical position of the mobile device in operation. This service is integral to the collection of real-time geographical data, commonly referred to as geodata, through the utilization of one or more location tracking technologies (Froehlich, 2022). These technologies include, but are not limited to, the Global Positioning System (GPS), Wi-Fi positioning, and cellular network triangulation. The primary objective of LBS is to acquire and process accurate geospatial information, enabling the customization of application features or content based on the user's current location. This functionality enhances the contextual relevance and utility of the mobile application. Notable applications of Location-Based Services encompass mapping and navigation utilities, location-based social networking platforms, and services offering personalized recommendations based on the user's geographic location.

Push

Push services operate by delivering information to users without a direct request or initiation from the user themselves. Such push services are activated by an event, which could be triggered if a specific area is entered or triggered by a timer. An example of an indirectly requested service is a news subscription that provides event information related to the user's current city. On the other hand, a service that is not requested could involve

receiving advertisement messages upon entering a specific area in a shopping mall or getting warning messages when weather conditions change, such as hurricane warnings. Since push services are not bound on previous user interaction with the service, they are more complex to establish. In this context, the push system must actively sense background information such as user needs and preferences or proactively provide information based on predefined criteria or events. This demands a more intricate system capable of gathering and interpreting the necessary background data.

Pull

Pull services deliver information directly requested from the user. A common analogy is akin to accessing a website on the Internet by entering its address in the web browser's address field. Pull services can be categorized into functional services, where specific actions such as ordering a taxi or an ambulance are initiated by simply pressing a button on the device, and information services, exemplified by activities like searching for a nearby Chinese restaurant (Steiniger et al., 2006).

Gradle

Gradle is an open-source build automation system primarily employed in software development to streamline and automate the process of building, testing, and deploying applications. Built upon the foundational concepts of Apache ANT and Apache Maven, Gradle distinguishes itself by providing a Domain-Specific Language (DSL) based on both Groovy and Kotlin. The tool utilizes tasks to represent atomic build activities, encompassing activities such as compiling source code, packaging JAR files, and generating Javadoc. The dependencies between these tasks form a directed acyclic graph

(DAG), facilitating the safe execution of tasks in parallel to expedite build execution (Liu et al., 2023).

The utility of Gradle extends beyond its core functionality. Its versatility and flexibility, notably through the incorporation of DSLs, establish it as a valuable and extensively utilized tool in the realm of build automation. This adaptability is particularly advantageous in the domains of software development, mobile development, and web development. Gradle's user-friendly interface, remarkable flexibility, and adept integration capabilities with a diverse array of technologies and frameworks further contribute to its widespread adoption in the development community.

Unity 3D

Unity 3D is a popular game development platform that offers a simplified approach to create various types of games. It provides an extensive set of tools and a robust physics system that simplifies the process of game development (Deep, et al., 2019). Augmented Reality (AR) can be seamlessly integrated with Unity 3D, enabling immersive experiences in different domains. For instance, in the field of Anatomy, Unity 3D combined with AR allows users to explore and study the intricate structures of the human body at any time and location (Du et al., 2015). Through Unity 3D's intuitive interface and the incorporation of AR features, individuals now can explore anatomical models, study detailed organ systems, and gain a deeper understanding of the human form. This breakthrough in medical education and visualization offers students, researchers, and healthcare professionals an innovative way to learn and engage with anatomical concepts, transcending the limitations of traditional textbooks or static visual aids.

Therefore, by harnessing the capabilities of Unity 3D and AR, the possibilities for immersive and captivating experiences extend far beyond the realm of games. The integration of these technologies opens new avenues for education, training, entertainment, and various other industries, transforming how we interact with digital content and perceive our surroundings. Ans as Unity 3D continues to evolve and AR technology advances, the potential for creating rich and engaging AR experiences becomes even more promising.

Unity Assets

Unity Assets are digital assets developed using the Unity game engine, encompassing 3D models, textures, scripts, audio files, and other resources used to build games and interactive experiences. It is a valuable resource for AR application development due to their extensive libraries, diverse offerings, and ability to streamline the AR development process. These libraries provide ready-made assets and tools that enhance the visual quality, interactivity, and overall user experience of AR applications. Key libraries include 3D Model Libraries, Texture Libraries, Script Libraries, Audio Libraries, AR-Specific Libraries and Utility Libraries. These assets can be purchased from the Unity Asset Store or created independently by developers. Unity Asset Store offers a variety of payment options, including individual asset purchases, subscriptions, and asset packs (Unity Technologies, 2023).

Unity Assets offers a multitude of benefits to game developers, including increased productivity, improved quality, and reduced risk. By providing ready-made assets, Unity Assets save developers time and effort, allowing them to focus on the more creative aspects of game development. Additionally, the professional-grade assets

available on the Unity Asset Store contribute to higher-quality games. Moreover, Unity

Assets help mitigate risks by eliminating the need for developers to create assets that may

not meet the desired standards and by providing assets that are licensed for commercial use

(Maning et al., 2019).

Prefabricated

In the Unity game engine, Prefabs act as reusable templates or models that

allow developers to streamline object and component creation (Unity Technologies, 2023).

These versatile tools are instrumental in generating a diverse array of items, spanning from

3D models to scripts and user interface elements. Particularly advantageous in augmented

reality (AR) model creation, prefabs offer seamless instantiation and integration into the

AR environment. To employ a prefab within an AR model, developers initiate its creation

within the Unity editor, effortlessly placing it into the AR scene via drag-and-drop or by

employing code for instantiation. Once integrated, the prefab assumes its designated

position within the AR landscape. By leveraging prefabs, developers benefit from saved

time and effort, harnessing pre-built assets for project implementation. Moreover, they

contribute to augmenting the quality of AR models through the provision of consistent,

well-crafted assets, while simultaneously promoting modularity and reusability within AR

designs.

Mapbox API

Mapbox API is a robust tool that grants developers access to mapping and location-

based services, enabling the seamless integration of dynamic maps and geographical data

into applications and websites. Its functionalities encompass a wide range, comprising

mapping, geocoding, routing, and navigation, thereby empowering developers to craft

personalized, interactive maps aligned with their precise requirements. Within its API,

developers have access to an extensive variety of map styles, ranging from standard street

maps to satellite imagery, and can extensively modify them by adjusting colors, integrating

markers, and layering data for effective information communication. Notably, its

adaptability extends across diverse platforms, spanning web, mobile, and AR/VR

applications. Additionally, the Mapbox API facilitates real-time updates, enabling the

display of live location data and swift adaptation to alterations. Its user-friendly interface

and comprehensive documentation simplify the integration process, providing developers

with a seamless approach to harness mapping capabilities. Moreover, the API's scalability

and performance guarantee the efficient management of substantial data volumes, ensuring

smooth user experiences across various devices and platforms, solidifying its position as a

favored choice for location-based services in numerous industries (Mapbox, 2023).

Mapbox SDK

The Mapbox SDK for Unity serves as a specialized toolkit merging

Mapbox's mapping and location-based services seamlessly into Unity-based applications.

This SDK empowers developers to integrate dynamic maps, incorporating diverse styles

from streets to satellite imagery, within their Unity environments. By leveraging Mapbox's

functionalities like geocoding and real-time location updates, developers can create

immersive experiences within their Unity applications. Acting as a link between Unity's

design capabilities and Mapbox's mapping services, this SDK enables the creation of

location-aware gaming experiences or applications within Unity's development

environment. Furthermore, it utilizes Unity's rendering capabilities to design visually

striking and interactive maps for games or simulations. According to Mapbox (2023), the

SDK efficiently combines Unity's gaming engine strengths with Mapbox's extensive

mapping functionalities, facilitating the creation of engaging experiences that seamlessly

integrate geographical data into Unity projects.

Mapbox Search Overview API

The Mapbox Search Overview API is a comprehensive set of tools offered

by Mapbox, specifically designed to facilitate efficient and accurate location-based search

functionalities within applications and platforms. This API provides developers with robust

capabilities for geocoding, enabling the conversion of user-entered addresses or place

names into precise geographic coordinates. Furthermore, it encompasses reverse

geocoding features, allowing developers to retrieve location-based information from

coordinates, such as addresses, place names, or specific points of interest. Through this

API, developers gain access to extensive location data and services, allowing for versatile

and tailored search experiences within their applications. Developers can implement search

functionalities that not only locate addresses but also identify nearby points of interest,

businesses, landmarks, and other relevant geographical information. The Search Overview

API stands as a powerful resource for developers seeking to integrate accurate and

comprehensive location-based search functionalities into their applications, enhancing user

experiences with precise and customizable search services (Mapbox, 2023).

Google Maps

Google Maps considered one of the most groundbreaking innovations in technology (Mehta et al., 2019), stands as a widely utilized mapping service providing comprehensive geographical data and navigation information for various applications (Google Cloud, n.d.). It offers detailed maps, satellite imagery, street views, and real-time traffic updates, catering to diverse needs, from simple address searches to complex navigation tasks, both on desktop and mobile devices. Users rely on Google Maps for route planning, exploring locations, finding businesses, and navigating unfamiliar areas (Google Cloud, n.d.; Mehta et al., 2019). Its versatile platform seamlessly integrates with GPS technologies, providing accurate location-based services worldwide.

Integrating Google Maps into system applications, especially mobile ones, involves leveraging its Application Programming Interfaces (APIs) tailored for Android and iOS platforms. The Google Maps SDKs for Android and iOS enable developers to embed maps, obtain location data, enable navigation, and integrate Street View into mobile apps. For web applications, the Google Maps JavaScript API allows developers to embed dynamic maps into web pages, customize map features, and integrate location-based services. These APIs empower developers to create interactive maps, implement geolocation functionalities, and provide turn-by-turn navigation within mobile applications. The integration of Google Maps APIs into systems applications significantly enhances user experiences by offering accurate geographical data and seamless navigation capabilities, making them invaluable tools for developers building location-aware and navigational features in mobile applications (Google Developers, n.d.).

Blender 3D

Blender 3D, an open-source software developed by the Blender Foundation, serves as a versatile and robust tool for creating 3D models, animations, and visual effects. In the realm of Augmented Reality (AR) applications, Blender proves instrumental in crafting and optimizing 3D assets for AR experiences. Its extensive suite of tools empowers developers to design intricate 3D models and animations suitable for integration into AR frameworks. By leveraging Blender's functionalities, developers can streamline 3D asset creation, ensuring compatibility with AR platforms. Through careful optimization within Blender, such as polygon count reduction and texture refinement, models become AR-ready, facilitating seamless integration into AR development environments. Blender's compatibility with various AR-friendly formats enables smooth exporting of assets into platforms like Unity or ARKit, where developers further refine the assets, incorporate interactivity, and embed them into the AR experience. Blender's adaptability and extensive toolset position it as a pivotal software for developers seeking to enhance AR applications with immersive and compelling 3D content ("Blender - a 3D modelling and rendering package," n.d.).

Software Quality Evaluation

In the field of software engineering, Estdale et al. (2018) discuss ISO 25010, also known as the Systems and Software Quality Requirements and Evaluation (SQuaRE) standard, as a widely recognized standard for evaluating software quality attributes. They emphasize the usefulness of ISO 25010 in providing a structured approach to assess various quality characteristics and ensure the delivery of high-quality software products.

The ISO 25010 serves as a comprehensive framework for evaluating software quality. It outlines eight primary quality characteristics, including functionality, reliability, usability, efficiency, maintainability, portability, compatibility, and security. These characteristics encompass a range of aspects that contribute to the quality of a software system.

Source: The ISO/IEC 25000 Functional Suitability.
(n.d.). https://iso25000.com/index.php/en/iso-
25000-standards/iso-25010

Figure 1. ISO 25010 Criteria: Characteristics and their Sub-Characteristics

To pass the ISO 25010 evaluation, a software system must demonstrate compliance with the defined quality characteristics and meet the specified sub-characteristics. This

requires implementing effective design, development, and testing practices to ensure the

desired level of quality is achieved (ISO/IEC 25010, n.d.).

By adhering to the ISO 25010 standard, software engineering practitioners can

establish a structured and standardized approach to evaluating software quality. It enables

them to identify areas of improvement, make informed decisions, and ensure the delivery

of high-quality software products that meet user expectations and requirements (Estdale et

al., 2018).

Related Studies

Several studies have explored the application of augmented reality (AR) technology

in the context of travel exploration and tourism, specifically focusing on revisiting

historical and cultural sites. These studies vary in their approaches and methodologies,

providing valuable insights into the design and implementation of AR-based systems.

In the local context, two studies have explored the use of AR for tourism in the

Philippines. Caluya et al. (2015) developed an AR-based mobile application that overlays

digital content on historical sites in Manila, including Fort Santiago. The study utilized

marker-based tracking, where users scan physical markers to trigger the AR content.

Similarly, Flores et al. (2020) created an AR system for cultural heritage sites in the

country, utilizing markerless tracking through Global Positioning System (GPS) or by

Geospatial Data.

Comparatively, studies from other countries offer different perspectives on AR-

based tourism. Maidi et al. (2020) conducted research in South Korea, developing an AR-

based smart tourism system that utilized markerless tracking and image recognition. Their

system provided real-time information and personalized recommendations to users based

on their preferences and location. In a study conducted in France, Kiel et al. (2013) focused

on using AR to enhance the interpretation of cultural heritage in museums. They employed

marker-based tracking and interactive storytelling techniques to engage museum visitors

and provide them with a deeper understanding of the artifacts.

The methods and systems employed in these studies demonstrate the versatility of

AR technology for tourism exploration. Marker-based tracking offers a straightforward and

accurate way of overlaying digital content onto physical sites, making it suitable for

historical locations like Fort Santiago. Markerless tracking, on the other hand, provides

more flexibility, allowing users to explore the environment freely without the need for

predefined markers. The hybrid approach combines the strengths of both tracking methods,

ensuring a robust AR experience for tourists.

The integration of personalized recommendations and real-time information based

on user preferences and location, as seen in the study by Maidi et al. (2020), enhances the

overall travel experience. Similarly, the interactive storytelling techniques employed by

Kiel et al. (2013) facilitate a more engaging and educational visit to cultural heritage sites.

By leveraging these methods and insights from existing studies, researchers intend to

develop a mobile application that explores these approaches, incorporating personalized

recommendations and interactive storytelling to offer tourists an immersive and

informative experience.

Challenges and Limitations of AR in Travel Exploration

Augmented Reality (AR) is a potential technology for improving trip exploring experiences. AR has the potential to alter the way people interact with their environment by superimposing virtual information on the actual world. However, using AR for trip exploration is not without its hurdles and restrictions. The purpose of this study of relevant literature is to look at the major difficulties surrounding AR application in the travel industry, such as technological constraints and hardware requirements, potential privacy and security concerns, accessibility issues, and cultural and ethical considerations.

There are various technological restrictions that prevent widespread end-user adoption of augmented reality in trip exploration. To fully experience the promise of AR in travel, one of the hurdles is the necessity for high-powered, fast smartphones with AR capabilities. Another issue is the requirement for object recognition technology to provide on-screen information about points of interest when a visitor walks through a city or town (C. Kounovis, 2012).

The acquisition and use of personal data is one of the possible privacy and security concerns of employing AR in travel exploration. AR systems may gather a wealth of data about the user and what they are doing. This information can include location data, photographs, and other personal information that, if not adequately protected, might be exploited for malevolent reasons (What are the Security Risks of VR and AR, n.d.).

Concerns have also been raised concerning the possibility of both physical and mental harm when the actual environment may be changed or completely replaced by digitally produced stuff (Dick, 2021). Furthermore, AR might serve as a testing ground for

large public usage of facial recognition, raising worries about potential privacy violations (Robertson, 2021).

There are various accessibility concerns and limitations to the use of augmented reality in trip exploration. Lack of access to AR/VR technologies and devices in communities representing persons with disabilities, limited AR/VR literacy, and inability to utilize AR/VR technologies owing to current lack of accessibility features are major challenges to AR/VR adoption (Creed et al, 2023).

When employing AR for travel, there are various cultural and ethical problems. There are ideas for providing ethical AR experiences at dark tourist locations before, during, and after a visit, for example. If spectacle is restrained at these gloomy settings, AR can become an ethical and compelling extension of pondering on mortality (Fisher and Bolter, 2023).

By superimposing virtual information on the actual world, augmented reality (AR) has enormous promise for improving trip exploring experiences. However, broad use of augmented reality (AR) in the tourism business confronts various hurdles. Technological limitations and hardware needs, such as the demand for high-powered smartphones with AR capabilities and object recognition technologies, impede the full fulfillment of AR's potential in travel. The capture and use of personal data by AR systems raises privacy and security problems, needing strong safeguards. Furthermore, potential physical and emotional injury, privacy violations through facial recognition, accessibility difficulties, and cultural and ethical factors complicate the usage of augmented reality in travel. Despite these challenges, overcoming them can result in ethical and engaging AR

experiences in trip exploration, making it a promising field for future study and development.

Research Gaps and Future Directions

A literature review conducted by Yung and Khoo-Lattimore (2017) revealed that many businesses, and even consumers, were still very hesitant to integrate VR/AR systems in their operations, resorting to their traditional ways. Further research on the effectiveness and impact of these intelligent systems to businesses would help bring awareness to the public, helping them embrace technological innovations and make use of them for their own benefit.

The state of AR in today's era is already looking bright because of countless innovative ideas developers have. However, there is always room for improvement in every field. "HMDs [Head- Mounted Displays] are still too clumsy and have limited field of vision, contrast and resolution," as Mekni and Lemieux (2014) stated. AR equipment should be light and easy to use, for user- convenience. Future enhancements should also be considered, such as time delays, misrecognition, system failures, etc. 5G network has already been introduced in the industry and this improvement might pave way for improvements and support to cloud-based AR (Amos, n.d.). Ideally, in the future, AR systems would be able to be utilized by the public anytime and anywhere in the world, personalized and easily accessible (Jabil, n.d.).

Conceptual Model of the Study

INPUT	PROCESS	OUTPUT
Knowledge Requirements: • Augmented Reality • Mobile Application Development • 3D Model Creation • Unity Engine • Blender 3D • A* Algorithm • Mapbox API • AR+GPS • Software Testing • Software Quality Evaluation **Software Requirements:** • ARCore • Unity3D • Blender 3D • ARToolKit • Figma • Adobe Photoshop **Hardware Requirements:** • Laptop/Desktop Computer • Processor: Intel Core i3-10110U or Ryzen 5 3500U RAM: 8GB DDR4, 2400 MHz Storage: 256GB or 512GB SSD, and 1TB HDD (optional) Graphics: Intel UHD Graphics, Radeon Vega 8, or Nvidia GeForce MX250 • Android Smartphone	**Requirement Analysis** **System Design** • Visual Table of Contents • System Architecture • Use Case Diagram • Program Flowchart Diagram **System Development** • Pseudocode **System Testing** **System Improvement**	**AN AUGMENTED REALITY-BASED TRAVEL GUIDE AND DIRECTORY APPLICATION FOR EXPLORING MANILA CITY**

EVALUATION

ISO 25010 Software Quality Evaluation
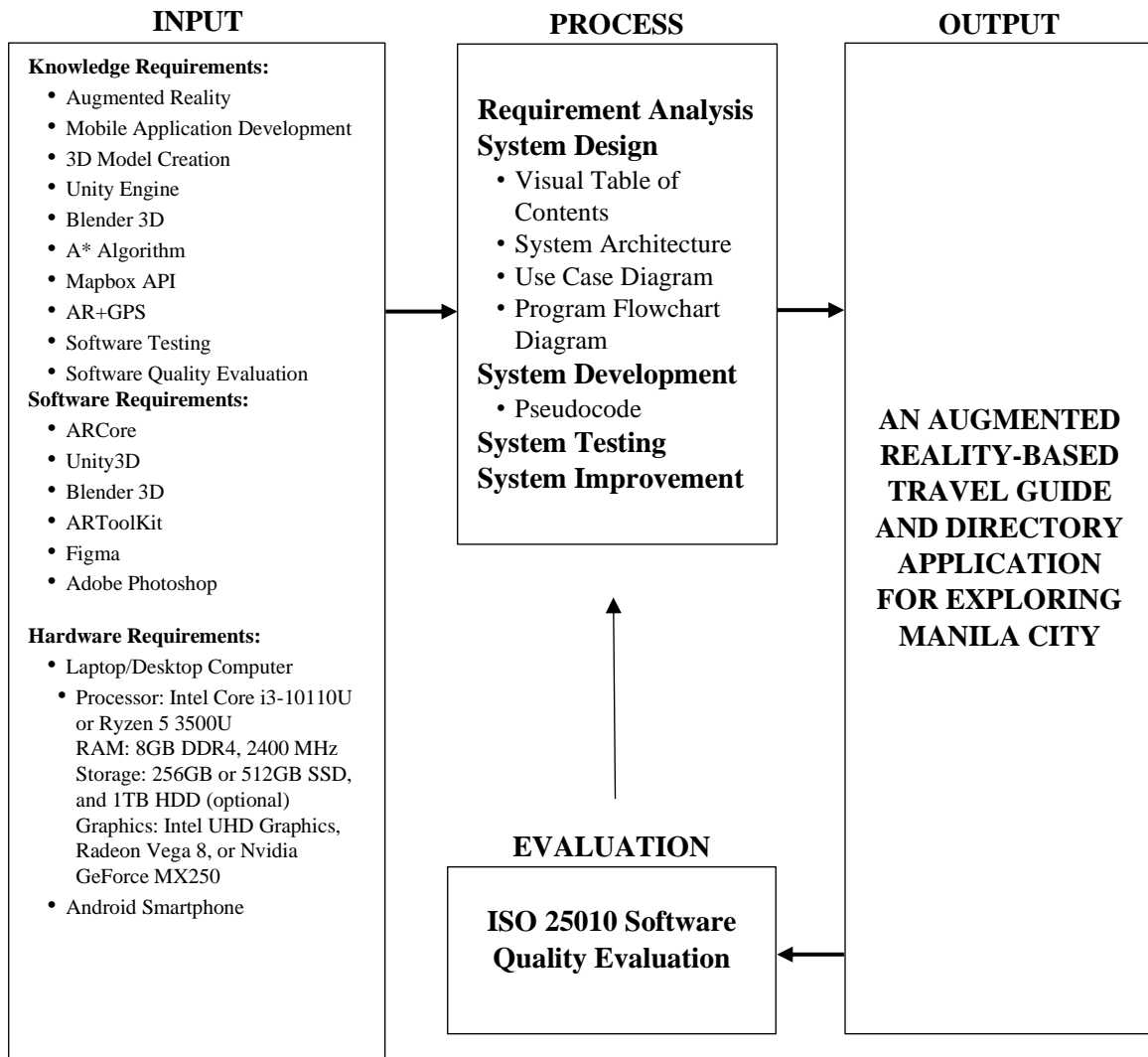
Figure 2. Conceptual Model of the Study

Input

The input block describes the knowledge, software, and hardware requirements for developing an AR-based mobile application for travel exploration. The knowledge requirements are the key concepts and skills that developers should possess to build the application successfully. These include expertise in Augmented Reality, Mobile

Application Development, 3D Model Creation, Unity Engine, Blender 3D, A* Algorithm,

Mapbox API, AR+GPS, Software Testing, and Software Quality Evaluation. The software

requirements outline the necessary software tools, frameworks, and platforms required for

the development process. These include Unity 3D 2022.3.24f1 which allows the

researchers to develop the augmentation of objects, ARCore and ARToolKit which are the

packages inside Unity that are required to install for the project, Blender 3D and Adobe

Photoshop are the tool for creating the 3D models, and Figma. The hardware requirements

specify the necessary physical devices for the project. This includes a Laptop/Desktop

Computer for development purposes and an Android Smartphone that is ARCore supported

for testing and running the AR application.

Process

The conceptual model follows all the stages of the Software Development Life

Cycle (SDLC). These stages include requirement analysis, system design, system

development, system testing, and system improvement: The system's functionalities and

necessary components are gathered during the Requirement Analysis phase to ensure a

comprehensive understanding for system development.

The System Design phase involves the creation of flowcharts, diagrams, and

preliminary designs for the system's front-end and back-end. This includes visual table of

contents, system architecture, use case diagram, and program flowchart diagram. The

system development phase translates requirements and designs into a functional system.

This involves building the application logic within Unity, scripting its behavior using an

Integrated Development Environment (IDE) like Visual Studio Code and creating the 3D

models of landmarks with Blender 3D. The system's functionalities are thoroughly tested

during the System Testing phase to ensure proper operation. This phase also includes a

performance evaluation of the system. Finally, the System Improvement phase provides

solutions to any problems discovered in the previous phase. This is also the stage at which

previous project build recommendations are discussed and implemented.

Output

From the given inputs and procedures, the outcome of the study was "Manila

ARventure: An Augmented Reality-Based Travel Guide and Directory Application for

Exploring Manila City." To ensure its acceptance, the output, particularly the mobile app,

underwent through ISO 25010 evaluation.

Operational Definition of Terms

- Tourism Directory – a comprehensive database containing information on tourist
  attractions, accommodations, dining options, and other services within a particular
  destination.

- Computer Vision – the field of AI that enables machines to interpret and understand
  the visual world.

- Android-based – a mobile application that has been particularly designed and built
  to work on devices running the Android operating system.

- Google's ARCore – a Software Development Kit (SDK) for building augmented
  reality (AR) experiences on Android smartphones. It includes APIs (Application
  Programming Interfaces) and frameworks that allow developers to integrate AR

capabilities into their Android applications, such as motion tracking, environmental comprehension, and light estimates.

- Unity3D – a popular cross-platform game engine and development framework for building Augmented Reality (AR) experiences. It offers a visual development environment as well as a variety of tools and capabilities for developing interactive and immersive AR apps for many platforms, including Android.

- ARToolKit – a free and open-source augmented reality tracking toolkit that includes tools and algorithms for marker-based tracking in AR applications. It lets developers identify and monitor certain markers or patterns in the real-world environment to precisely overlay digital material.

- GitHub – a web-based version control and collaboration tool for software development projects. It serves as a repository for hosting code, monitoring changes, and promoting developer communication. It enables effective administration of source code, documentation, and project materials.

- Augmented Reality (AR) – a technology that overlays digital information, such as images or data, onto the real world.

- Markerless AR – a type of Augmented Reality (AR) technology that does not require physical markers to overlay digital content onto the real world.

- Gradle – a build automation tool used in the development of software applications.

- Unity 3D – a game development platform used for creating 2D and 3D experiences.

- Mapbox API – a suite of APIs offering mapping, navigation, and location search services.

- Google Maps – a web mapping service offering satellite imagery, street maps, and

  route planning functionality.

- Blender 3D – a software tool used for 3D modeling, animation, and rendering.

Chapter 3

METHODOLOGY

This chapter tackles the methodology used in various aspects of the study, including the project design, project development, operation and testing procedure, and evaluation procedure.

Project Design

This section serves as the foundational blueprint that outlines the structure and functionality of the research. The comprehensive design of the project is encapsulated through the Visual Table of Contents (VTOC), System Architecture, System Flowchart, and Software Design.

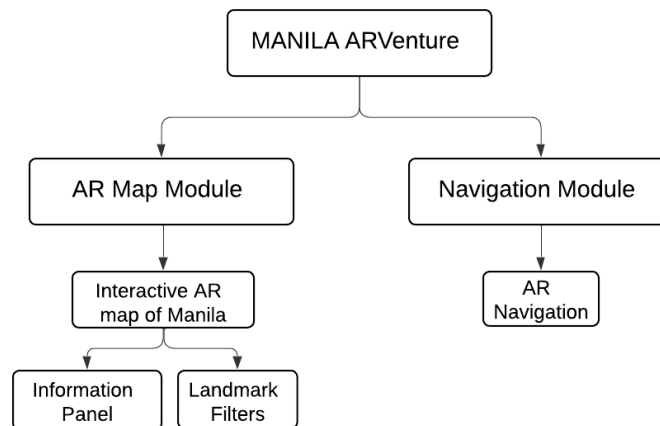*Visual Table of Contents*

Figure 3. Visual Table of Contents of the Manila AR.Venture Mobile Application

The AR Manila Map module serves as the primary interface for users to explore Manila through augmented reality. Upon launching the application, the system scans for

plane detection, which triggers the AR map to appear. This map is populated with clickable

3D landmark models that are various points of interest around the city. Users can interact

with these models to open an information panel that provides detailed descriptions about

each landmark. Additionally, this panel features a "Navigate" button that, when pressed,

transitions the user to the AR Navigation module. To enhance user experience, the module

includes filter options that allow users to display landmarks based on specific categories

such as sights, churches, parks, and shops.

System Architecture
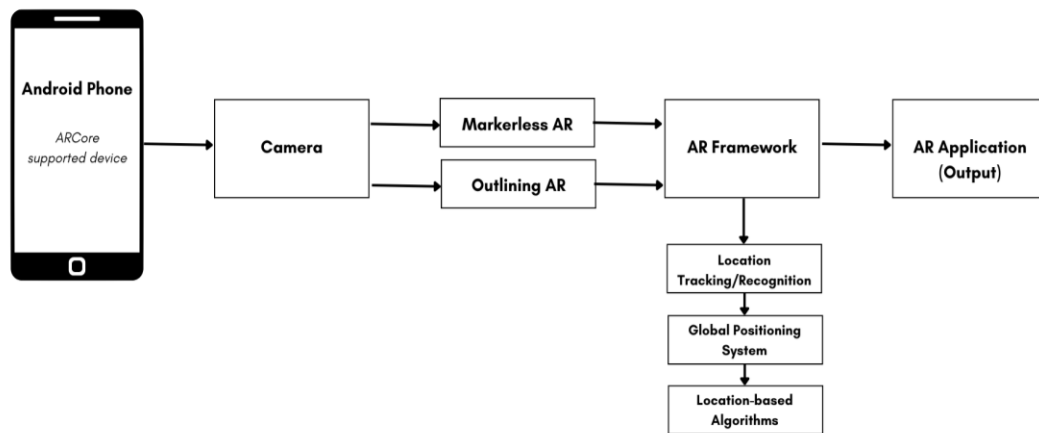
Figure 4. System Architecture

The system architecture, as shown in Figure 4, illustrates how to seamlessly

integrate various software tools and technologies within our mobile application for an

immersive and informative tourist experience in Manila City, as well as how the system

obtains the necessary information for the Augmentation component within the mobile

application. The mobile phone or device used should be an ARCore supported device to

deliver an optimal AR experience and enhance the object augmentation process. The

camera captures the live video feed that serves as the background for the Augmented

Reality (AR) experience. For augmentation, the application utilizes two types of content,

namely the Markerless AR and the Outlining AR. The input undergoes processing within

the AR Framework. Within this framework, multiple processes occur, including location

tracking/recognition, which is filtered by location-based algorithms. The AR Framework

utilizes GPS sensors to acquire the device's current location. This location data undergoes

further refinement through location-based algorithms, ensuring precision and consistency

for location-specific AR experiences, such as placing virtual objects at designated

landmarks. The processed output from the AR Framework is rendered and displayed on

the mobile device's screen. However, for the AR application to function correctly, location

access and camera permission must be granted by the user. This permission allows the

application to access the device's GPS data, enabling location-based AR features and

ensuring an accurate and localized AR experience.

System Flowchart

The flowchart system developed based on augmented reality design is as follows:
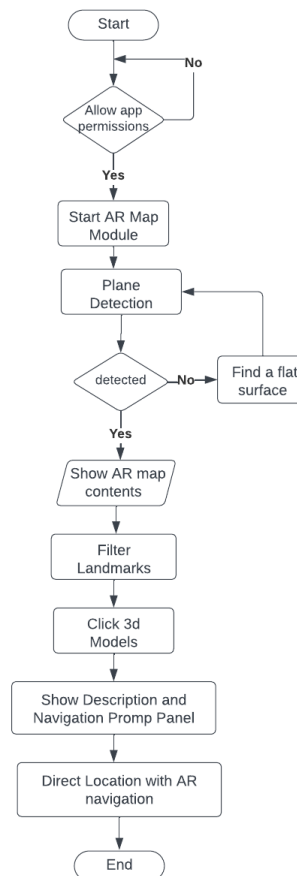
Figure 5. System Flowchart

The process begins by checking if the GPS and camera permission is enabled. Once the app permissions are enabled, the application initiates plane detection in the user's surroundings. Upon successful plane detection, an augmented reality (AR) map highlighting Manila's landmarks, categorized as sights, parks, churches, and malls, is displayed. Users can then filter these landmarks within the city. Selecting a landmark prompts the AR system to present a description of the chosen location, along with an optional prompt for directions. This will then lead the user to experience AR directional

navigation. The user's interaction with the application's features is concluded upon completion of the navigation process.

Software Design

Figure 6. Software Design

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

1. Application Initialization:

- Users initiate their experience by opening the application, which serves as the entry point to the augmented reality-based travel guide.

2. Exploration Mode:

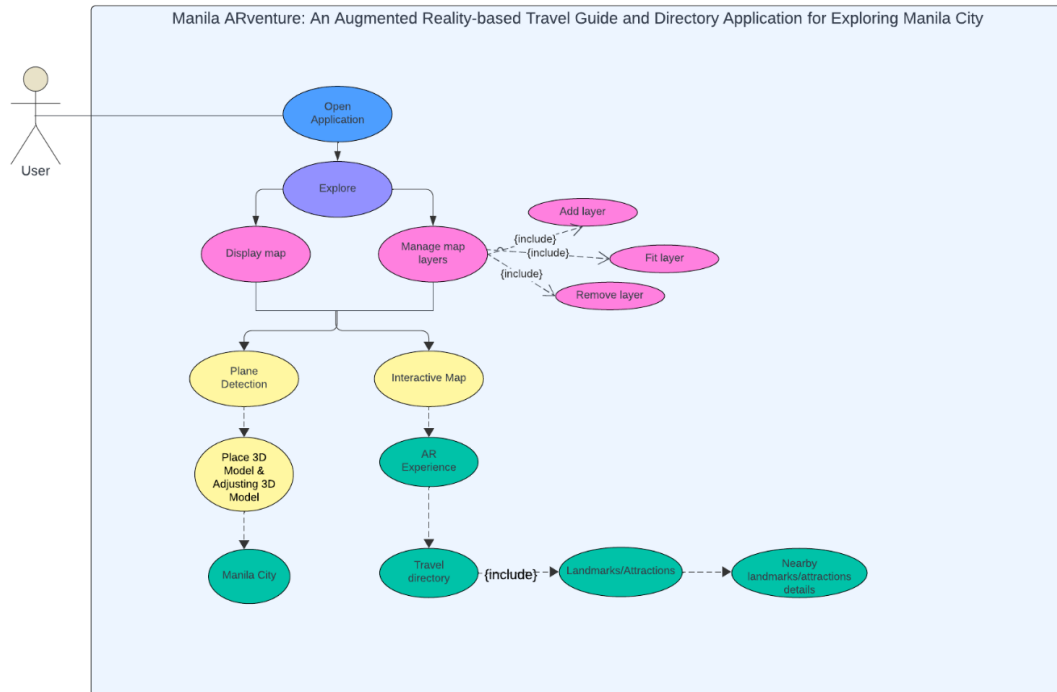- Upon launching the application, users are presented with the option to explore various features of the application, primarily focusing on map-related functionalities.

3. Map Display:

- The primary feature is the display of the Manila City map. This map serves as the central interface for users to access information and engage with the interactive elements of the city.

4. Map Layer Management:

- Users have the capability to manage different layers of the map, enhancing their viewing and interactive experience.

5. Interactive Map Feature:

- The interactive map is a core component of the application, offering an augmented reality (AR) experience. This feature allows users to interact with the map in a dynamic and immersive way, bringing the city to life through augmented reality.

6. Plane Detection and 3D Model Placement:

- The application incorporates advanced plane detection technology, enabling users to detect flat surfaces in their environment.
- Users can place 3D models on these detected planes and adjust them as necessary. This feature provides a realistic and interactive representation of Manila City within the user's physical environment.

7. Travel Directory Integration:

- The application includes a comprehensive travel directory that provides users with detailed information about various landmarks and attractions within Manila City.

- The travel directory is integrated with the AR experience, allowing users to explore landmarks and attractions directly from the interactive map.

- Users can access detailed information about nearby landmarks and attractions, including historical data, visitor information, and other relevant details, enriching their exploration experience.

These detailed features ensure that the Local Tourism Industry guide using the Augmented Reality Mobile Application offers a robust, interactive, and informative tool for users to explore and discover Manila City in an engaging and technologically advanced manner.

Project Development

This section involves the systematic implementation of the outlined objectives, translating conceptual ideas into a tangible and functional application, providing a detailed account of the strategies, tools, and methodologies employed throughout the development process.

Implementation Strategy

The project used the Agile Model as the basis for the whole development process. The Agile Model is an iterative approach wherein development tasks are broken down into smaller pieces, aiming to progress through each in a short amount of time, while allowing

changes and modifications at any point of the development. This approach gave the

researchers more flexibility towards the project, making it more manageable and viable.

Consequently, this provided lower risk, as risks were mitigated at each iteration.

Coding and Programming

AR Map Module

1. Set up Unity3D, which will serve as the development environment.

2. Design the map with Mapbox, adding markers, layers, and other elements needed.

3. Use the Mapbox API in the Unity project to fetch the map data from Mapbox.

4. Set up a basic map in Unity using Mapbox prefabs.

5. Import the 3D models of tourist spots and destinations, designed using Blender3D,
   in the Unity project.

6. Use Unity's AR tools to enable interactions with the AR map, such as tapping on
   elements and viewing details.

7. Integrate the filtering method to filter the 3D elements shown in the map based on
   the user's choice.

Navigation Module

1. Gather road data of Manila City.

2. Parse road data to extract needed information: nodes, edges, costs of edges

3. Create a script in unity to implement the A* algorithm.

4. Integrate A* script to the AR + GPS asset to calculate shortest distance for the user.

This actual script from Unity section presents the A* algorithm for finding the shortest path

to travel from a point in Manila City to a landmark destination presented by nodes.

A* CODE

```
private void BuildShortestPath(List<Node> list, Node node)
    {
        if (node.NearestToStart == null)
           return;
        list.Add(node.NearestToStart);
        ShortestPathLength += node.Connections.Single(x => x.ConnectedNode
== node.NearestToStart).Length;
        ShortestPathCost += node.Connections.Single(x => x.ConnectedNode ==
node.NearestToStart).Cost;
        BuildShortestPath(list, node.NearestToStart);
    }

public List<Node> GetShortestPathAstar()
    {
        foreach (var node in Map.Nodes)
           node.EuclideanDistance = node.EuclideanDistance(End);
        AstarSearch();
        var shortestPath = new List<Node>();
        shortestPath.Add(End);
        BuildShortestPath(shortestPath, End);
        shortestPath.Reverse();
        return shortestPath;
    }

private void AstarSearch()
    {
        NodeVisits = 0;
        Start.MinCostToStart = 0;
        var prioQueue = new List<Node>();
        prioQueue.Add(Start);
        do {
           prioQueue = prioQueue.OrderBy(x => x.MinCostToStart +
x.EuclideanDistance).ToList();
           var node = prioQueue.First();
           prioQueue.Remove(node);
```

```
              NodeVisits++;
              foreach (var cnn in node.Connections.OrderBy(x => x.Cost))
              {
                var childNode = cnn.ConnectedNode;
                if (childNode.Visited)
                   continue;
                if (childNode.MinCostToStart == null ||
                   node.MinCostToStart + cnn.Cost < childNode.MinCostToStart)
                {
                   childNode.MinCostToStart = node.MinCostToStart + cnn.Cost;
                   childNode.NearestToStart = node;
                   if (!prioQueue.Contains(childNode))
                      prioQueue.Add(childNode);
                }
              }
              node.Visited = true;
              if (node == End)
                 return;
            } while (prioQueue.Any());
          }
```

User Interface (UI) Design

The application's user interface was designed using Figma. UI elements, such as the main screen, drawers, etc. Further customization and styling with the application's color schemes, fonts, and other visual elements was carried out as needed.

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 or enable the Location Access and Camera Permission of the phone.

3. Point your phone's camera to a flat surface.

4. An Interactive Map will appear.

5. **A. For Filtered Landmarks** – There are filtered landmarks: sights, parks,

   church, shops. By clicking one of these options, the user can select the filtered

   places they want to go. Focus the back camera of the android mobile device on

   the vicinity of the designated location and augmented objects will appear.

   B. To go to a certain location – In the Interactive Map, select the landmark you

   wish to visit. Within the landmark's description, there is a "Navigate" button.

   When clicked, this button activates the system to display the walking route,

   guiding you step-by-step to your chosen location.

6. View and observe the map 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 2.

A. Functional Suitability

TEST CASE	STEPS UNDERTAKEN	EXPECTED RESULTS	TYPES
Trigger Mechanisms	a) Point the device's camera at a flat surface to activate the AR map. b) The AR map should automatically activate upon plane detection.	The application reliably detects a suitable plane and activates the AR map.	Functional Appropriateness

TEST CASE	STEPS UNDERTAKEN	EXPECTED RESULTS	TYPES
AR Map Display and Functionality	a) Scan the trigger and observe the AR map's simulation of the physical map. b) Test the filtering function for different landmark categories.	The AR map accurately simulates the physical map, displays landmarks, and successfully filters for specific landmarks.	Functional Appropriateness Functional Correctness
AR Model Interaction	a) Click on an AR model and check for the appearance of a description and direction prompt.	Clicking on an AR model prompts the display of a description and direction prompt related to the landmark.	Functional Appropriateness Functional Correctness User Interface Aesthetics

Table 3.

B. Performance/Usability/Efficiency

TEST CASE	STEPS UNDERTAKEN	EXPECTED RESULTS	TYPES
AR Map Loading Time	a) Measure the time taken for the AR map to load after trigger activation.	The AR map loads within an acceptable time frame after trigger activation.	Time Behavior
Filter Response Time	a) Test the speed and responsiveness of the filtering functions within the AR map.	The filtering functions respond promptly within the AR map.	Time Behavior Resource Utilization

Table 4.

C. Maintainability/Portability/Design

TEST CASE	STEPS UNDERTAKEN	EXPECTED RESULTS	TYPES
System Stability	a) Engage the AR application for an extended duration. b) Execute various interactions and functionalities within the application. c) Monitor for system crashes or errors.	The application remains stable without any crashes or errors during prolonged use and diverse interactions.	Availability Fault Tolerance Recoverability
User Interface Consistency	a) Interact with different features and screens within the AR application. b) Analyze the interface design, navigation flow, and consistency.	A coherent, intuitive, and uniform user interface design and navigation throughout the application.	User Interface Aesthetics Accessibility

Evaluation Procedure

Evaluation Instrument

To evaluate the acceptability of the developed helmet detection application, reseearchers utilized the ISO 25010 standard, specifically focused on systems and software quality requirements and evaluation. This evaluation procedure aims to ensure that the application meets the required quality standards.

Researchers introduced and explained every feature of the Manila AR.Venture application to 30 respondents representing diverse community sectors—Tourists, Students, Manila residents, and IT Professional, then the following steps was taken to assess the acceptability of the application:

1. **Criteria Explanation:** Researchers provided evaluation sheets based on ISO/IEC 25010 or a similar product quality evaluation system. Detailed explanations of the evaluation criteria was offered to ensure respondent comprehension.

2. **Evaluation Sheet Completion:** Respondents used a 4-point Likert scale to rate the application's performance against the provided criteria on the evaluation sheets.

3. **Data Collection:** Compiled evaluation sheets was collected for further analysis and data consolidation.

4. **Tabulation and Computation**: Tabulated data from individual respondent evaluations was computed to derive the overall frequency and results for each criterion.

5. **Results Interpretation**: Using predefined numerical rating tables, computed results was interpreted to assign descriptive ratings, offering a comprehensive assessment of the application's quality and performance.

Table 5.

The 4-point Likert Scale for Evaluation

Scale	Adjectival/ Descriptive Rating
4	Highly Acceptable
3	Very Acceptable
2	Acceptable
1	Not Acceptable

The evaluation utlized a 4-point Likert Scale, as depicted in Table 5. This includes adjectival ratings and scales to assess the system across various categories aligned with ISO 25010 characteristics. The 4-point Likert Scale was employed to elicit users' opinions as it does not provide a safe or neutral option, compelling participants to express their viewpoint (Cornell, 2022).

Statistical Method

For statistical analysis, the frequency was determined by tallying the occurrences of participant responses under specified conditions. The overall percentage was computed by utilizing the formula illustrated below and subsequently be interpreted using the numerical rating scale presented in Table 5:

$$\% = \left(\frac{f}{n}\right) \times 100$$

Where:

- *f* represents the frequency of responses.

- *n* signifies the total number of respondents.

Table 6 exhibits the scale ranges applied in evaluating the percentage criteria, aiding in the interpretation and assessment of collected data.

Table 6.

Numerical Range and Its Qualitative Interpretation

Numerical Rating	Adjectival/ Descriptive Rating
76%-100%	Highly Acceptable
51%-75%	Very Acceptable
26%-50%	Acceptable
0%-25%	Not Acceptable

Chapter 4

RESULTS AND DISCUSSION

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

Project Description

Manila AR.Venture is a mobile app designed to enrich the travel experience in Manila. Using augmented reality (AR), the app blends digital information seamlessly with the user's surroundings, offering interactive maps, step-by-step directions, and detailed information about key landmarks. The app's innovative features include efficient route planning powered by the A* algorithm, interactive maps created with Mapbox technology, and the placement of realistic 3D landmarks within the user's view using ARCore.

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.

Figure 7. Landing Page   **Figure 8.** Interactive AR Map Module

The application as shown in **figure 7** has a landing page that navigates to a single

module—the interactive AR map as seen in **figure 8.**
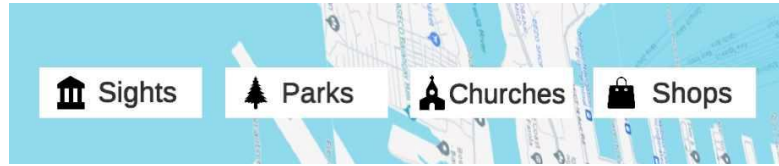
Figure 9. Category Buttons

The interactive AR map has 4 buttons located at the top area, as shown in **figure

9**. These buttons trigger the 3d landmark display on the map depending on where they are

categorized.

Figure 10. "Sights" Category   **Figure 11.** "Parks" Category
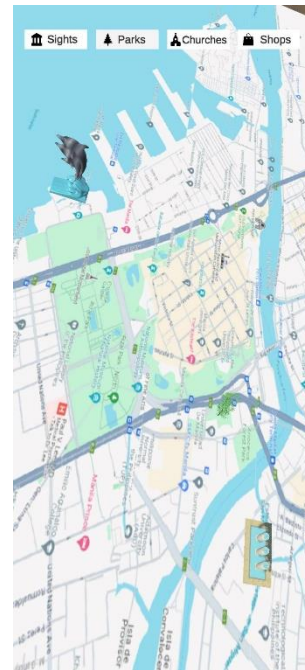
Figure 12. "Churches" Category

Figure 13. "Shops" Category

Shown in **figures 10,11,12** and **13** are the effect of these buttons to the

interactivity of the AR map.
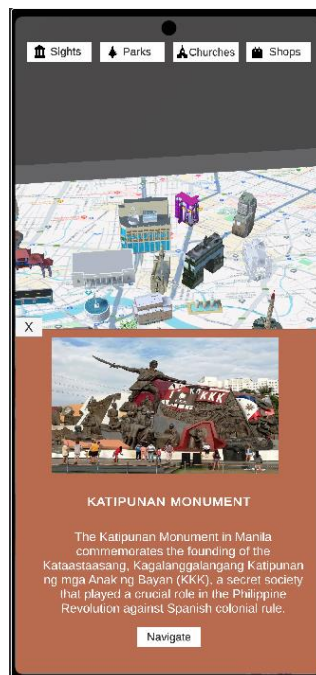
Figure 14. Pop-up Panel on 3D Landmark click

Figure 14 presents the display upon clicking a 3d landmark, revealing a panel

which describes the landmark, and a navigation button to prompt direction.

Figure 15. AR Navigation

Figure 15 describes how the user experience AR navigation upon clicking

navigate button from the panel.

Project Capabilities and Limitations

Manila AR. Venture has the following capabilities:

1. The application displays Augmented Reality (AR) objects for each landmark on

   the map.

2. Display Augmented Reality (AR) object outlining routes covering the listed

     landmarks.

3. The application allows users to filter landmarks by categories such as sights,

     parks, churches, and shops for easier exploration.

4. The application provides detailed information for each landmark destination.

5. Integration of A* algorithm to assist users in navigating to specific landmarks.

6. The pathfinding algorithm calculates the shortest and most efficient path to the

     user's chosen destination.

7. Provides users with the remaining distance to their destination (in meters) based

     on the calculated route.

8. Provides users with directions and visual cues to guide them to their destination.

9. The application offers a user-friendly interface designed for easy navigation and

     interaction.

10. Interactive AR experiences and detailed visualizations enhance user engagement

     and make exploring Manila City more enjoyable.

The application's limitations are the following:

1. The application can only be used in Manila City, Philippines.

2. The application and maps cannot be used offline.

3. The application can only be used with ARCore supported Android phone devices.

4. The application only covers a limited number of landmarks in Manila City. 19

     Sights,   3 Parks, 4 Churches, and 10 shops.

5. The navigation feature is limited to walking routes.

6. The app does not account for roadblocks, one-way streets, or other traffic

conditions in its navigation guidance.

Test Results

Table 7.

A.   Test Results on the Functional Suitability of the Application

MODULE	STEPS UNDERTAKEN	OBSERVED OUTPUT
(Functional Appropriateness & Functional Correctness) Trigger Mechanism	a. Open the application b. Allow camera access c. Scan surroundings, point the device's camera at a flat surface. d. Move the device away from the flat surface. e. Observe the output.	The application reliably detected a suitable plane and anchored the AR map to the surface, displaying landmarks of Manila City.
(Functional Appropriateness & Functional Correctness) AR Map Display and Functionality	a. Open the app and allow camera permissions. b. Point the device's camera at a flat surface and wait for the AR map to appear. c. Observe the displayed landmarks and tap the category buttons (Sights, Parks, Churches, Malls). d. Observe how the map reacts to category selections.	The AR map accurately simulated the physical map with the interactive 3d model. Tapping category buttons correctly filtered the displayed landmarks, showing only those belonging to the selected category or categories.
(Functional Appropriateness) AR Model Interaction	a. Open the app and allow camera permissions. b. Point the device's camera at a flat surface and wait for the AR map to appear. c. Tap on one of the 3D landmark models. d. Observe the UI for any changes.	Tapping on an AR model successfully displayed a description and direction prompt related to the landmark.

Table 8.

B. Test Results on the Performance/Usability/Efficiency of the Application

MODULE	STEPS UNDERTAKEN	OBSERVED OUTPUT
(Time Behaviour) AR Map Loading Time	a. Open the app and allow camera permissions. b. Point the device's camera at a flat surface and wait for the AR map to appear. c. See how long it takes from plane detection to full map rendering.	The AR map loaded within an acceptable time after plane detection.
(Time Behavior & Resource Utilization) Filter Response Time	a. Open the app and allow camera permissions. b. Point the device's camera at a flat surface and wait for the AR map to appear. c. Tap on different category buttons to filter landmarks. d. See the time taken for the map to update and display the filtered landmarks.	The filtering functions responded promptly, and the map updated quickly to show the filtered landmarks.

Table 9.

C. Test Results on the Maintainability/Portability/Design of the Application

MODULE	STEPS UNDERTAKEN	OBSERVED OUTPUT
(Availability, Fault Tolerance, & Recoverability) System Stability	a. Open the app and allow camera permissions. b. Engage the AR features for an extended period, including plane detection, landmark interaction, and navigation. c. Perform various actions like filtering landmarks, tapping on	The application remained stable throughout the extended testing period, with no crashes, errors, or noticeable

	models, and prompting the navigation panel. d. Check the app for crashes, errors, or performance degradation	performance degradation saw.
(User Interface Aesthetics & Accessibility) User Interface Consistency	a. Open the app and allow camera permissions. b. Trigger AR map. c. Interact with various features of the application, such as filtering landmarks, tapping on AR models to view details, and accessing the navigation drawer. d. Assess the consistency of visual elements, layout, navigation patterns, and terminology across different screens and functionalities.	The user interface kept a coherent, intuitive, and uniform design and navigation flow throughout the application.

Project Evaluation

The Manila AR. Venture: An Augmented Reality-based Travel Guide and Directory Application for Exploring Manila City was assessed to gauge its acceptability. The participants included students, tourists in Manila, residents of Manila, IT professionals, and professionals in the tourism sector. The table below provides a summary of the evaluation results.

Table 10.

Summary of Evaluation

Criteria	Mean	Adjectival Rating
Functional Suitability		
a. Functional Correctness	3.23	Very Acceptable
b. Functional Appropriateness	3.63	Highly Acceptable
Criteria Weighted Mean	3.43	***Highly Acceptable***
Usability		
a. Operability	3.31	Very Acceptable
b. User Error Protection	3.10	Very Acceptable
c. User Interface Aesthetics	3.83	Highly Acceptable
Criteria Weighted Mean	3.41	***Highly Acceptable***
Portability		

a. Installability	3.30	Very Acceptable
b. Replaceability	3.48	Highly Acceptable
Criteria Weighted Mean	3.38	***Very Acceptable***
Performance Efficiency		
a. Time Behavior	3.21	Very Acceptable
b. Resource Utilization	3.76	Highly Acceptable
c. Capacity	3.40	Highly Acceptable
Criteria Weighted Mean	3.45	***Highly Acceptable***
Grand Mean	3.41	***Highly Acceptable***

Table 10 shows that the Manila AR. Venture Traveling and Directory

Application, a mobile application, scored best in the "Performance Efficiency," with a

weighted rating mean of 3.45, is classified as "Highly Acceptable." This suggests that

both the augmentation method and accuracy were adequate. "Functional Suitability"

received a weighted grade of 3.43, which is classified as "Highly Acceptable" and

suggests that Manila AR.Venture fulfilled its stated purpose of making travel easier and reducing time spent in the area.

The Manila AR. Venture obtained the third-highest ranking under "Usability," with a weighted rating mean of 3.41, which is characterized as "Highly Acceptable." This shows that users were able to experience an augmented reality scenario and learn about the interactions between real-world items and settings through the usage of the smartphone application.

Under "Portability" category with a weighted mean of 3.38, yet it was still classified as "Highly Acceptable." This suggests that further functionality, such the ability for users to run applications on platforms like Android and Apple/iOS (with other versions supported by depth sensors), may be improved in the future.

As a summary of the findings, Manila AR. Venture obtained a weighted average mean of 3.41, which is classified as "Highly Acceptable," meaning that users found the application to be highly acceptable as an educational travel tool that might ease their travels throughout Manila City.

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

This research contributes significantly to the field of tourism exploration by pioneering "Manila AR.Venture", an Android mobile application leveraging the power of Augmented Reality (AR). Developed using Unity, Blender 3D, Visual Studio, and Mapbox SDK, this application directly addresses the challenges faced by tourists navigating and accessing comprehensive information within Manila City.

Manila AR. Venture eliminates the traditional reliance on physical maps and tourist guides, empowering users with intuitive AR technology for seamless navigation. Furthermore, the application transcends mere directional assistance by unlocking a wealth of comprehensive information about Manila's landmarks. By leveraging the use of smartphones, users gain the ability to embark on a self-guided exploration, uncovering the rich historical and cultural narratives woven into Manila's landmarks. This innovative application represents a significant paradigm shift in the domain of tourist exploration. It transforms the experience into one that is not only engaging and enriching but also fosters a more profound understanding and appreciation for Manila City.

In line with the results of the evaluation, the application garnered the following findings:

● **Test Results**

1. **Functional Suitability.** The test results indicate that the application functioned as intended. The AR map triggered reliably upon plane detection, accurately displaying landmarks relative to the user's location. Filtering landmarks by category and activating the navigation drawer with route information operated correctly.

2. **Performance/Usability/Efficiency.** The application performed well overall. The AR map loaded within a reasonable time frame, and filtering and navigation features were responsive. The navigation drawer opened smoothly, and the map loaded efficiently.

3. **Maintainability/Portability/Design.** The application exhibited strong stability, remaining crash-free and error-free during prolonged use and diverse interactions. The user interface was consistent across different screens and functionalities, maintaining a coherent design and navigation flow.

● **Evaluation Results**

1. **Functional Suitability.** The respondents evaluated the Manila AR. Venture as highly acceptable as how the application worked and helped on less travel time of the user, reducing the time spent in the area, and experience an informative tourist application.

2. **Usability.** The respondents evaluated Manila AR. Venture as highly acceptable as 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 Manila AR. Venture as highly acceptable as it how it works in selected Android Devices with Depth API.

Conclusions

The study successfully accomplished its objectives by designing and developing "Manila AR.Venture," an Android mobile application that leverages augmented reality to revolutionize the way tourists explore Manila. The application seamlessly integrates an augmented reality map, featuring interactive 3D landmarks that appear upon plane detection, providing users with an immersive and informative experience.

The intuitive filter feature empowers users to tailor their exploration by categorizing landmarks into various types, enhancing convenience and personalization. By simply clicking on a 3D landmark, users can access detailed descriptions, enriching their understanding of Manila's cultural and historical significance.

Furthermore, the implementation of outlining augmented reality significantly enhances navigation within the city, guiding users towards their desired destinations with ease. The efficient pathfinding algorithm, utilizing the A* search algorithm, ensures that users can discover the shortest routes, optimizing their travel experience.

Evaluation of the application's components using the ISO 25010 standard demonstrates high levels of functional suitability, usability, portability, and performance efficiency. These findings underscore the effectiveness of "Manila AR.Venture" as a comprehensive and user-friendly tool for exploring Manila, offering significant value to both tourists and the local tourism industry.

Recommendations

The following are the recommendations of the study:

1. That the application will be improved by:

a. Incorporating an itinerary feature that allows users to create and customize their own travel plans based on their interests, time constraints, and budget.

b. Integrating restaurants and other points of interest (e.g., cafes, bars, shops) into the AR map and providing search functionality to help users discover new places.

c. Adding a feature to view the map in 2D along with a live street view with AR.

d. Integrating with local transportation schedules and updates to provide real-time transit information

e. Integrating real-time weather data into the app.

f. Introducing an emergency contact feature for quick access to local emergency services.

g. Introducing offline mode for basic functionalities when internet connectivity is unavailable.

h. Including a virtual tour guide that provides audio descriptions of landmarks.

i. Expanding the landmark categories to cover more diverse points of interest.

j. Providing multi-language support to cater to international tourists.

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Appendix A

EVALUATION INSTRUMENT

Email *

Your email

Name *

Your answer

Do you agree to participate in this study? *

○ Yes

○ No

What role do you take in this study?

○ Tourist in Manila

○ Resident in Manila

○ Student

○ IT Professional

○ Tourism Sector Professional

○ Other:

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 AR application precisely augments AR landmarks on the AR map when a flat surface is *
detected. **(Functional Correctness)**

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

The AR application allows users to effectively filter and explore landmarks by categories such *
as Sights, Hotels, Restaurants, and Parks, ensuring ease of use and relevance. **(Functional Appropriateness)**

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

The AR application provides clear and accurate navigation directions to selected landmarks, *
improving the user's ability to reach their destinations. **(Functional Correctness)**

	1	2	3	4	
Not Acceptable	○	○	○	○	Acceptable

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)*

	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 display AR objects when a flat surface is not detected, ensuring *
accurate and relevant augmentation. *(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 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 application 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. *

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

Appendix B

SAMPLE ANSWERED EVALUATION SHEET

Email *

dominguezralphriche@gmail.com

Name *

Ralph Riche

Do you agree to participate in this study? *

⦿ Yes

◯ No

What role do you take in this study?

◯ Tourist in Manila

◯ Resident in Manila

⦿ Student

◯ IT Professional

◯ Tourism Sector Professional

◯ Other:

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 AR application precisely augments AR landmarks on the AR map when a flat surface is detected. *(Functional Correctness)* *

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

The AR application allows users to effectively filter and explore landmarks by categories such as Sights, Hotels, Restaurants, and Parks, ensuring ease of use and relevance. *(Functional Appropriateness)* *

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

The AR application provides clear and accurate navigation directions to selected landmarks, improving the user's ability to reach their destinations. *(Functional Correctness)* *

	1	2	3	4	
Not Acceptable	○	○	○	○	Acceptable

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)* *

	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 display AR objects when a flat surface is not detected, ensuring accurate and relevant augmentation. *(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 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 application 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. *

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

Comments and Suggestions

Thank you for getting this far and contributing to our Capstone Project!

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

Submitted 5/30/24, 2:39 PM

Appendix C

THESIS GRAMMARIAN CERTIFICATION

		Index No.	
(logo)	**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	Revision No.	
		Effectivity Date	
VAA-COS	**THESIS GRAMMARIAN CERTIFICATION**	Page	

This is to certify that the thesis entitled,

**MANILA AR.VENTURE: AN AUGMENTED REALITY-BASED
TRAVEL GUIDE AND DIRECTORY APPLICATION
FOR EXPLORING MANILA CITY**

authored by

Jeorge Irey G. Dans
John Denzil A. Dimaguila
Mika Ena L. Gajeto
Janah Patricia O. Morano

has undergone editing and proofreading by the undersigned.

This Certification is being issued upon the request of Jeorge Irey G. Dans, John
Denzil A. Dimaguila, Mika Ena L. Gajeto, and Janah Patricia O. Morano for whatever
purposes it may serve them.

MS. FRANZE NAVARRO OROCEO
Grammarian

Technological University of the Philippines

June 13, 2024

Transaction ID	
Signature	

Appendix D

TURNITIN CERTIFICATE

	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES	Index No.	F-URD-4.1-CSI
	Ayala Blvd., Ermita, Manila, 1000, Philippines	Issue No.	01
	Tel No. +632-301-3001 local 711	Revision No.	00
	Email: urds@tup.edu.ph | Website: www.tup.edu.ph	Date	07102023
VRE-URD	CERTIFICATE OF SIMILARITY INDEX USING TURNITIN	Page	1 / 1
		QAC No.	CC-07102023

This is to certify that the manuscript entitled

**"MANILA AR.VENTURE: AN AUGMENTED REALITY-BASED
TRAVEL GUIDE AND DIRECTORY APPLICATION FOR EXPLORING
MANILA CITY"**

Authored by

**JEORGE IREY G. DANS
JOHN DENZIL A. DIMAGUILA
MIKA ENA L. GAJETO
JANAH PATRICIA O. MORANO**

College of Science

has been subjected to similarity check on June 13, 2024
using Turnitin with generated similarity index of 9%.

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 F

CURRICULUM VITAE

JEORGE IREY G. DANS

Computer Science Major
Manila City, PH | +639670786882 | jeorgedans30@gmail.com

EDUCATION

Balian Integrated National High School	Bachelor of Science in Computer Science Aug. 2020 –
STEM Jun. 2013 – Jul. 2020	Present
• Junior High School Graduate with Honors	• President's/Dean's Lister (A.Y 2020 – Present)
• Senior High School Graduate with High Honors	• Relevant coursework: Computer Programming, Data Structures and
• Batch 2020 Best in Work Immersion Awardee	Algorithm, Object Oriented Programming, Information Management, Design
	Analysis of Algorithm, Artificial Intelligence, and Web Development
Technological University of the Philippines – Manila	

WORK & LEADERSHIP EXPERIENCE

Google Developer Students Club
Manila City, Philippines
Chief Relations Officer
December 2022 – Present
• Leads strategic planning with the COO, prioritizing member, and executive benefits. Cultivates relationships and oversees key roles within the external connection department.

Department of Labor and Employment
Pangil, Laguna, Philippines
Human Resource Officer
July 2022 – August 2022
• Led comprehensive recruitment processes, from interviews to onboarding, while effectively managing pay and leave matters.

Department of Labor and Employment
Pangil, Laguna, Philippines
Employment Service Officer
June 2021 – July 2021
• Oversees and coordinates welfare operations and programs across retail, factory, and industrial settings, collaborating with maintenance and operations teams for seamless implementation.

Department of Labor and Employment
Pangil, Laguna, Philippines
General Service Officer   May 2018 –
June 2018
• Managed all aspects of physical resources and logistics, including procurement, warehouse operations, inventory, leasing, transportation, and staff supervision.

PROJECTS

Development of Real-time Helmet Detection System using YOLOv8 Computational Mechanism
July 2023
• Awarded as TUP – M Software Festival's Best System (2023)
• Gathered relevant database sets for training and testing.
• Implemented YOLOv8 for helmet detection.
• Modeled the training process, optimization, and documentation of development results

Handwritten Mathematical Expression Recognizer Using Neural Network
February 2023
• Acquired diverse mathematical expression datasets and trained models.
• Identified and resolved code and model errors, optimizing performance.

Web Profanity Filter Using Regular Expression

February 2023
• Investigated profanity filtering methods for web content.
• Gathered profane language datasets and designed regular expressions.

PICK-A: Choosing Through Different Meal Courses using Copeland's Method
February 2023
• Researched decision-making methods for meal selection.
• Designed the user interface for input and display.
• Collected data on meal preferences and options.

Student Election System

September 2021
• Created a student election system that uses ID cards and USB flash drives as voting keys.

SKILLS

KEY SKILLS
Web Development, Predictive Modeling, Deep Learning, Computer Vision, NLP, Machine Learning, and Data Analytics
Resourcefulness, Problem Solving, Fast Learning, Adaptability, Communication, Attention to details, Creativity

TECHNICAL SKILLS
Programming Languages: C/C++, Python, HTML, CSS, JavaScript, Frameworks: Tailwind CSS, React JS, Angular & Flask
Analytics: Excel, SQL, Python, R, Tableau, Excel/VBA
Others: MS Office, Git, Github, Canva, Figma

CERTIFICATIONS

• Coding Bootcamp of Zuiit (#03316)
• DataCamp Introduction to Python (#27,093,582)
• DataCamp Understanding Data Science (#27,067,793)
• Sololearn Python (CT-N6NINJVD)
• Programming Fundamentals by Duke University (Issued Sept. 2021)
• Sololearn C Course (1089-2146679)

JOHN DENZIL DIMAGUILA

Manila, PH | denz.dimaguila@gmail.com | 09568052778 | LinkedIn

EDUCATION

Technological University of the Philippines | Manila   *September 2020 - Present*
Bachelor of Science in Computer Science
- DOST-SEI Merit Scholar
- Consistent Dean's and President's Lister
- Class President / Representative (2022-2023)

Laguna College | San Pablo City, Laguna   *August 2020*
Science, Technology, Engineering, and Mathematics (STEM)
- With Honors

ORGANIZATIONS

The Philippine Artisan (Official Student Publication) | TUP Manila   *2023 - 2024*
Junior Staff Video Editor

DOST Scholars' Club | TUP Manila   *2023 - 2024*
Technical Working Committee Member

TECHNICAL SKILLS

Programming Languages:
- C / C++
- Python
- SQL

Software Development Tools:
- Code::Blocks
- MS Visual Studio
- MS Visual Studio Code
- Arduino Software

Areas of Proficiency:
- Software Development
- Machine Learning / AI
- Data Analytics

Soft Skills:
- Problem Solving
- Quick Learning
- Attention to Detail
- Independence
- Leadership

Other Skills:
- MS Office
- Video Editing
- Photo Editing

PROJECTS

- Handwritten Mathematical Expression Recognizer using Neural Network   *Feb 2023*
- Real-time Helmet Detection System using YOLOv8 Computational Mechanism   *Jul 2023*
- PhilHealth Online Registration Form using VB.NET and SQL   *Jul 2022*
- Student Election Voting System using C   *Sep 2021*

MIKA ENA L. GAJETO

Bachelor of Science in Computer Science
Technological University of the Philippines (Manila)

PROFILE

A consistent honor student who is eager to learn at all times. A hardworking individual with a commitment to succeed while being open to criticisms and challenges. Loves to gain new knowledge and working on projects that focuses on communication and collaboration.

CONTACT

PHONE:
09173348392

ADDRESS:
San Francisco(Halang) Binan City, Laguna

EMAIL:
mikagajeto@gmail.com
mikaena.gajeto@tup.edu.ph

LINKEDIN:
www.linkedin.com/in/mikagajeto

SOFT SKILLS

Highly organized and efficient
Ability to motivate
Adaptability
Fast learner
Time Management

HARD SKILLS

Visual Basic
Adobe Photoshop
Adobe Premiere Pro
C/C++
HTML
CSS
JavaScript
Python
Figma

EDUCATION

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES (MANILA)
Ayala Blvd., corner San Marcelino St., Ermita, Manila 1000
2021–PRESENT
4th YEAR 1st SEM - President's Lister

SANTA ROSA SCIENCE AND TECHNOLOGY HIGH SCHOOL
J.P Rizal Blvd. Barangay Market Area, Santa Rosa City, Laguna, 4026
2014–2020
Junior High School (Grade 10): Graduated with Honors
Senior High School (Grade 11): With High Honors
Senior High School: Graduated with Honors

WORK EXPERIENCE AND ORGANIZATIONS

Frontier Tower Associates Philippines
March 2024 – PRESENT
IT Intern

Go!Foton Micro Optics Philippines
2019
Work Immersion

Special Program of the Employment of Students (SPES)
May 2019 – June 2019

Google Developers Student Clubs
Technological University of the Philippines – Manila
2023 - PRESENT
External Relations Lead

DOST Scholars' Club
2022 – PRESENT
Member

Women in AI Philippines
2021- PRESENT
City Lead (Binan City)

TUP Tech Guild
Technological University of the Philippines – Manila
2021 – 2022

AWARDS AND CERTIFICATIONS

Back-end Web Development 101 Training Certification
BPI Technical-Vocational Program (BPI Foundation and Bayan Academy)
September 2022 – October 2022

Best in Research in Software Engineering Festival — *"Development of Real-time Helmet Detection System using YOLOv8 Computational Mechanism"*
Technological University of the Philippines – Manila
July 2023

Iskolar ng Laguna Scholar
2021 – PRESENT

DOST JLSS Scholar
2022 – PRESENT

JANAH PATRICIA MORANO
COMPUTER SCIENCE MAJOR

0929-6714-761 (Globe) / 0968-237-5681 (Smart) | jpatriciamorano@gmail.com | janahmorano | janahmorano

Profile

Dynamic and driven computer science student seeking an internship to leverage technical proficiency in software development and programming. Eager to contribute innovative solutions, collaborate with a team, and gain practical experience in a professional setting.

Skills

KEY SKILLS

Data Analytics · Machine Learning · NLP · Computer Vision · Predictive Modeling · Deep Learning · Web Development
Problem-solving· Creativity · Attention to details · Communication · Adaptability · Fast learning · Resourcefulness

TECHNICAL SKILLS

Programming   C++/C · Python · HTML · CSS · JavaScript · PHP · Framework: Angular & Flask
Analytics   Python · SQL · Tableau · Power BI · Excel/VBA · R · Excel
Productivity   Photoshop · MS Office · Canva · Figma

Projects

Real-Time Motorcycle Helmet Detection System using YOLOv8 ↗ (TUP-M Software Festival's Best System 2023)
- Conducted training and testing on a dataset of 1341 images using YOLOv8 in Python with Google Colab.
- Achieved a mean average precision of 83% in helmet detection accuracy.
- Applied the model for safety compliance, detecting prohibited motorcycle helmets within establishments.

TxtEase: Document Organizer Web Application ↗
- Developed Flask-based web application utilizing K-Means clustering for document organization.
- Supported document formats: DOCX, TXT, and PDF, facilitating seamless management by their content topic.
- Enabled users to download organized document clusters in ZIP format, enhancing workflow efficiency.

Covid-19 Cases and Spread Tracker ↗
- Used raw data to create a dashboard that shows world's Covid-19 cases trends and death percentage per country.
- Cleaned the raw data from inconsistent formats.
- Utilized MS SQL to make queries for data visualization and Tableau for creating Dashboard.

Responsive Multi-Page Ecommerce Web Site ↗
- Crafted a responsive multi-page ecommerce perfume store website.
- Integrated features like shopping cart, wish list, and product quick view for enhanced user experience.
- Implemented a multi-role-based login system, checkout order form, and admin dashboard using HTML, CSS, JavaScript, PHP, and MySQL.

Dali Everyday Store Simulation
- Modeled and simulated store processes and waiting times at Dali Everyday Grocery Store using the M/M/1 queuing model.
- Developed a Simio-based simulation model closely reflecting real-life observations with a P-value of 0.13.
- Identified the effectiveness of deploying two cashiers during peak hours, resulting in short waiting times of approximately 19 seconds, offering key insights for optimizing the queuing system and improving customer service.

Experience

Omdena
JUNIOR MACHINE LEARNING ENGINEER   Jan. 2024 - Present
- Collaborating with a global team of AI engineers on an ESG risk assessment project, focusing on collecting and processing climate-related data for European regions.
- Playing a vital role in developing a robust, georeferenced database and creating an automated pipeline for continuous data collection and processing.

Google Developer Student Clubs TUP-M
INTERNAL RELATIONS OFFICER   Aug. 2023 - Present
- Manages email communication and collaboration with other college organizations within TUP Manila Campus to establish partnerships and secure sponsorships for GDSC.
- Facilitates email blasts to inform and engage GDSC members about upcoming events and activities.

Neodocto Inc.
ASSOCIATE DATA ANALYST INTERN   Sep. 2022 – Dec. 2022
- Collaborated with a team of interns to conduct data collection, cleaning, scraping, and preprocessing activities.
- Contributed to the efficient gathering and preparation of data for analysis and decision-making.

Education

Pasay City National Science High School   **Technological University of the Philippines Manila**
STEM   Mar. 2013 – Apr. 2019   BACHELOR OF SCIENCE IN COMPUTER SCIENCE   Aug. 2020 – Present
- Junior Highschool Graduate with Honors   - President's/ Dean's Lister (A.Y. 2020-Present)
- Senior Highschool Graduate with Honors   - DOST Scholar

Certifications

- Certified Lean Six Sigma White Belt (# CERT_KKSH6VLX)
- Accenture Data Analytics and Visualization (#EWXRgFrCMAQp7dcbD)
- DataCamp Intermediate SQL Queries (#25,649,836)
- Google Data Analytics Professional Certificate (#QA7MSH2BNFCX)
- DICT-WD002 Using HTML and CSS to Design a Website (#7af73f89-728c-4309-95af-f4137bcd01b6)
- DICT Programming for Intermediate Users Using Python (#3a4f55ca-d3e4-46f5-a691-f09d1261ad89)