Development of guiding virtual reality at the Sultanate Palace in North Maluku as cultural tourism content

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A B S T R A C T

Virtual reality is a new phenomenon that has rapidly developed over the past few years, while studies on the development of virtual reality in cultural objects such as sultanate palaces are still very few, so further studies are needed. This research aims to develop virtual reality as a guiding and promotional media for cultural tourism of the sultanate palace in North Maluku, especially the sultanate palace of Ternate and Bacan. The steps in developing virtual reality consist of 3 steps. First, take the original image of the palace using drones and cameras. The second step is the development of 3D objects of the sultanate palace using Blender. The third step is application development using Unity and Virtual Reality tools: Smartphones and Cardboard. This research uses the SDLC Waterfall method. Testing in this study uses four stages of the testing process: (1) black box test, (2) media expert test, (3) expert test, and (4) UEQ (User Experience Questionnaire) test. The result of this research is that the availability of virtual guiding applications for the Bacan and Ternate Palaces has created an immersive cultural virtual tourism experience.

A R T I C L E  I N F O

Keywords:
Tourism, Virtual Reality, Cultural Tourism, Sultanate Palace, North Maluku

JEL Classification:
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Introduction

North Maluku is an integral part of the history of the entry of Spanish, Portuguese, Dutch, and English colonizers. Foreign nations travel across vast oceans in search of new lands with natural potential or to expand their territories, which are then for the colonists as fields to reap profits. Moluku kie raha or Maluku kie raha is the motto or designation for Maluku, which was later transformed into North Maluku with four mountains, namely Ternate, Tidore, Makian, and Moti. In addition, key raha refers to the North Maluku islands, which have four significant kingdoms that are also important pillars of the course of royal government in North Maluku, namely Ternate, Tidore, Jailolo, and Bacan. Since ancient times, North Maluku has become a vital spice trade center in the archipelago. The development of North Maluku was greatly influenced by traders who came to exchange their merchandise for cloves and various spices from North Maluku. Trade in cloves attracts the attention of immigrants from within and abroad.

Maluku is famous for its beautiful clove flowers; many foreigners are interested in coming there to trade. Even Europeans came to want to control the region. In addition, Maluku is also known as the Land of a Thousand Islands and Jazirah al-Mulk (the territory of kings) (Darmawijaya, 2010). Access to Maluku is effortless because Maluku is one of the centers of international shipping traffic in the archipelago, besides Malacca and Java. At first, Maluku included Ternate, Tidore, Makian, and Moti. The four regions are called "Moloku Kie Raha," meaning the union of the four Kingdoms. In the 13th century AD, several Solano (kingdoms) already appeared in Maluku that played an essential role in the field of trade, namely Ternate, Tidore, Makian, and Moti. On the next trip, after the treaty of Moti in the 14th century AD, Kolano Makian moved to Bacan, and Kolano Moti moved to Jailolo.
Since then, four kolano in Maluku changed their names to Ternate, Tidore, Bacan, and Jailolo, and of those four, it was Kolono Ternate and Tidore that received much attention in the coverage of Islamic history in Maluku. Ternate’s kingdom was famous during Sultan Khairun and Sultan Baabullah, while the sultanate of Tidore was during Sultan Nuku. Until now, the palace of the Moluku Kie Raha Sultanate still stands tall and has become an icon of the region that continues to be preserved and become one of the cultural and historical tourist destinations. In historical objects, some things that support tourist activities are the needs of tourists known as triple S, namely Something to see, which means there is something that can be seen at the tourist attraction; Something to do, which means there is something that can be done at the attraction; Something to buy something that can be bought at the tourist attraction (Arjana, 2015). Based on Law of the Republic of Indonesia No. 11 of 2010 concerning cultural heritage is artificial and natural objects that are at least 50 years old, which represent a particular style period and a style time of at least 50 years, and have essential value for history, science, and culture (Government of Indonesia, 2010).

The condition of Indonesia's tourism development relies on specific main tourist destinations, although other regions are believed to have a diversity of tourism potential. North Maluku has a sultanate palace that can be a unique and distinctive cultural tourism destination, but until now, it has not been widely known in the community. In the industrial era 4.0, information technology is the key to business success. Information Technology plays a vital role in human life. Likewise, the tourism industry cannot be separated from information technology, so people, as potential tourists, are currently exposed to information technology, especially virtual reality. Virtual reality is a promotional medium for tourist destinations by prioritizing consumer experience. Virtual reality is also conceptualized as a technology that allows users to interact with the environment in a virtual world simulated by a computer so that users feel in the environment (Fang & Lin, 2019; Rauscher, 2020). Virtual reality erases the natural world around humans and makes the user feel herded into a virtual world entirely out of touch with the natural world (Cheeyong et al., 2017; Gonçalves et al., 2022).

This research was conducted to promote North Maluku tourism, which is devoted to the sultanate palaces of Ternate and Bacan through virtual reality. Virtual reality can also be a guiding tour to introduce tourists to the sultanate palace in North Maluku. This is the first research conducted in Indonesia with a focus on developing virtual reality in the sultanate palace as a guiding and promotion of cultural tourism.

**Literature Review**

**Culture and Tourism**

Culture and tourism have always been inextricably linked. Culturally based tourist attractions and events provide important motivation to visit (Richards, 2013). When viewed in terms of culture, the tourism industry indirectly contributes to the development of Indonesian culture because, with a tourist attraction, it can introduce cultural diversity owned by a country, such as traditional arts, religious ceremonies, or customs that attract the attention of foreign tourists and Indonesian tourists. The rapidly developing tourism industry provides intercultural understanding and understanding through the relationship of tourist visitors (tourists) with the local community where the tourist area is located. One type of tourism that uses cultural resources as the principal capital of tourist attractions is called cultural tourism.

Cultural tourism allows tourists to directly contact local people with exceptional knowledge about a cultural object. This type of tourism provides extensive knowledge regarding culture, ranging from performing arts, festivals, traditional food, fine arts, history, past experiences, and other ways of life. Tourism today can be said to be a necessity of modern human life because of technological advances and information that continues to develop. The attractiveness of cultural tourism has not been developed much in academic studies. Ethnic culture and historical heritage are still often seen as the core attraction of cultural tourism. In academic studies, new terminology emerges, such as heritage tourism, which in Indonesian terminology is almost no different from cultural tourism.

**Virtual Reality and the Palace of the Sultanate**

Virtual reality is a powerful and exciting technology that aims to mimic the real world with a computer-generated environment and engage all the senses (Hsiao et al., 2021; Huang & Wang, 2022). Many types of virtual reality have been formed, such as digital heritage, training simulations, virtual concerts, and others (Monterroso-checa et al., 2020; Samah et al., 2021). Compared to traditional graphics research, virtual reality technology emphasizes the interaction between the user and the system. Users can log in and experience a digital environment in real-time, feeling like they are there for real (Pestek & Sarvan, 2020; Sun & Tsai, 2021).

In virtual reality, there is a part that we often call a virtual tour because it has virtual reality elements, namely virtual navigation of landscapes that exist in the real world (Gössling, 2020; Huang & Wang, 2022; Ma, 2021). Virtual tours are technology to simulate a location, usually using video or images. In addition, it can be developed from panoramic photo media with an uninterrupted view. These techniques are used to develop virtual tours derived from virtual reality created by computers to produce virtual world experiences (Deng et al., 2020; Garcia et al., 2018; Laine, 2018). Virtual reality created in a virtual tour has three ways to shape it: first, making the natural environment virtual through three-dimensional modeling. This is widely seen in three-dimensional games. Second, photography techniques that combine the environment into one unbroken image, for example, 360° and panorama. The third is a combination of the two methods above. How to form a virtual tour has been widely applied in previous research (X. Li et al., 2022; Su & Chen, 2022; Zhang et al., 2018)

Virtual tours for tourism still apply to many forms.
Panorama: Virtual tour research has several elements: navigation, background sound, description voice, and description text. Such elements are used on each hotspot in the virtual tour (Pehlivanides et al., 2020; Singla, 2021). The application is based on the website using the Easypano Tourweaver application, which supports Flash 11 Player. This study uses a desktop flash player application to run it so it can only be opened through the desktop. This study discusses the topic of historical places, namely the Sultanate Kerator in North Maluku, namely the Sultanate Palace of Ternate, Tidore, Bacan, and Jailolo.

The difference from previous research is in making up the software used to create virtual tours. Virtual tours are made real like the original site. The Zamani project creates Topography using three-dimensional models (Gonçalves et al., 2022). The model was made real because the texture was taken based on photos of the design of the Palace building or the tourist site. User navigation using walk-through and camera perspective using first-person view. The creation of this application uses three-dimensional Unity software (X. Li et al., 2022; Su & Chen, 2022; Sun & Tsai, 2021) combined with the results of the complete building design of the palace based on SketchUp.

Making a three-dimensional virtual tour has challenges in three-dimensional models because you have to think about the model, which is still guaranteed to load quickly. Therefore, polygon reduction in the model is essential. The fewer polygons, the lighter the model size. This technique is called low polygon in modeling (H. Li, 2022). However, the problem with vertex texturing is that the model must be high-resolution for texturing to look attractive. UV texture mapping is the solution because a separate texture can cover the low polygon model (Lv, 2022).

Developing a three-dimensional virtual tour website application in the property sector uses the basis of making three-dimensional models such as Petra, Jordan's virtual tour research. The navigation used is a walk-through and camera perspective using a first-person view. The difference between the application to be made from previous research is first using WebGL (Website et al.) for its three-dimensional graphics (Gonçalves et al., 2022; Singla, 2021). WebGL is the standard for creating three-dimensional visualizations on websites. WebGL uses JavaScript for OpenGLES (Open et al.), allowing three-dimensional graphics without plugins. HTML5 can be set on Firefox, Chrome, opera, and safari (Samah et al., 2021). WebGL can be used on desktop, mobile, and other platforms that support OpenGL or OpenGL@ES 2.0. Its application uses the Three.js library because it is easier to operate WebGL. Three.js also supports importing models from three-dimensional applications such as three-dimensionalMax, SketchUp, Blender, etc.

Research and Methodology

This research was conducted with the object of research in the sultanate palace in North Maluku. In this study, the samples were the palace of the Sultanate of Ternate, located in Ternate City, and the Bacan, located in South Halmahera Regency. The development of the virtual reality application of the sultanate of North Maluku includes research on the development of Research and Development. Research and Development is a method used to produce specific products and test the effectiveness of those products. This research method emphasizes research capabilities in making a product through materials, media, learning tools, and strategies or educational engineering. The model used in this study is Waterfall.

The development of virtual reality to promote cultural tourism of the sultanates of Ternate, Tidore, Bacan, and Jailolo uses the SDLC (Software et al.) software development life cycle in linear sequential or waterfall models. The Software Development Life Cycle, often referred to as the SDLC system, is the process of developing or changing a software system using models and methodologies used by people to develop previous software systems (based on best practices or well-tested methods) (Handayani & Setiawan 2019; Humayun et al., 2022; Mohino et al., 2019). In the SDLC cycle, security plays a vital role. Software security testing is an essential means to achieve the goal of secure SDLC, which is considered a framework in software development (Siregar, 2020).

The waterfall model SDLC method is a sequential software development process, where each stage must be completed first before entering the next stage, which is seen as a flow of water that continues to flow through the existing stages, namely the stages of analysis, design, code and tests (Handayani &; Setiawan, 2019; Yudi Purnawan et al., 2019) as can be seen in the figure below.

![Figure 1: Waterfall Stages in the Developed Application](image-url)
Results and Discussions

This research aims to develop a virtual guiding application (cultural virtual tourism) for the Unity-based Bacan and Ternate Palaces using the Software Development Life Cycle (SDLC) method. This application will provide an immersive experience for users interested in exploring and understanding the unique culture and history of two famous palaces in Indonesia. The development of these applications involves several stages, including planning, design, coding, testing, implementation, and operation and maintenance. Field data is also taken directly from the location of each palace to ensure accurate and in-depth information about relevant cultural and historical aspects is integrated into the application. In addition, the development of this application also involves several platforms, such as SketchUp and Blender, to design building designs, and Unity to bring Virtual Reality (VR) and Interactive Reality (IR) experiences. This application will be run on the Oculus Quest 2 device as a medium to provide a realistic and immersive VR experience for users.

With the combination of SDLC and the integration of various platforms, it is hoped that the virtual guiding application for the Bacan and Ternate Palaces can provide an authentic, interactive, and informative experience for users. The results discussion stage will discuss the application development process, evaluation of research objectives, and the benefits and potential of developing this application in the future.

![Figure 2: Stages of making an application](image)

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Picture</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Foris Ici</td>
<td><img src="image" alt="Foris Ici" /></td>
<td>Foris Ici is a room used as a family room, guest entertaining room, and dining room. In the Foris Ici room, two rooms face each other, two rooms on the left and two more rooms on the right.</td>
</tr>
<tr>
<td>2</td>
<td>Foris Lamo’s room</td>
<td><img src="image" alt="Foris Lamo’s room" /></td>
<td>Foris Lamo’s room was a meeting place between the sultan and the ministers. There is one room in the foris lamo room, opposite each other. This room has a table containing props for the daily rituals of</td>
</tr>
</tbody>
</table>
Foris lamo

Monday and Thursday nights and a unique table that holds many souvenirs from guests.

3 Balcon

The balcony room has two exits; each door has stairs named Kore Mia and Kore Sara. The balcony is a room mortgaged as a place to receive guests and a place for families to relax.

Picture of the building front view of the palace of the sultanate of Ternate

The implementation of research is divided into several stages: planning, design, data collection in the form of photo data of the research location, and object information based on interview results. Furthermore, the data is implemented into object 3; here are some collected data.

Table 2: Table of data collection of the palace of the Sultanate of Bacan

<table>
<thead>
<tr>
<th>Objects</th>
<th>Total</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throne</td>
<td>2</td>
<td><img src="image1.png" alt="" /></td>
</tr>
<tr>
<td>Table</td>
<td>1</td>
<td><img src="image2.png" alt="" /></td>
</tr>
<tr>
<td>Quran</td>
<td>10</td>
<td><img src="image3.png" alt="" /></td>
</tr>
</tbody>
</table>
The collected data is converted into 3-dimensional objects using several platforms such as Sketchup and Blender, starting with designing objects or building objects according to their original shape.
Image 1: Front view of Ternate Palace

Image 2: Interior Images of Keraton Ternate

Image 3: Front View Image

Image 4: Living Room Images
Coding

Virtual Tour Guide Development and Interactive Content (Implementation): This coding phase will include the development of a virtual tour guide and additional interactive content based on pre-made designs. VR Control and User Interface (Deployment) Integration: At the implementation stage, VR controls will be integrated with pre-designed interactions. In addition, an intuitive user interface will be developed to allow users to navigate, choose routes, and access additional information quickly. Here is a look at the prototype application that has been completed.
After the coding, a testing phase is carried out to ensure the application runs appropriately and is free from bugs or other problems. The development team will conduct simulation and live testing using the Oculus Quest 2 device to ensure the app works correctly and provides a comfortable VR experience.

**System Testing and Analysis**

I am testing this research application using the Blackbox model, which helps test every use and feature contained in the application. More details can be seen in the table below.

![Image 7, 8, 9: Historical images of photos in the Keroton Building](image)

<table>
<thead>
<tr>
<th>No</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Input</th>
<th>Expected Output</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Home Testing</td>
<td>Check if the app's homepage is working correctly.</td>
<td>&quot;Start,&quot; &quot;About,&quot; and &quot;Exit&quot; buttons</td>
<td>Homepage view with options</td>
<td>Pass</td>
</tr>
<tr>
<td>2</td>
<td>Tour Guide Testing</td>
<td>Test interactions with virtual tour guides.</td>
<td>Click on the virtual tour guide character</td>
<td>The tour guide provides information</td>
<td>Pass</td>
</tr>
<tr>
<td>3</td>
<td>Navigation Testing</td>
<td>Check navigation between locations within the app.</td>
<td>Click on navigation buttons, maps, etc.</td>
<td>Move to the selected location</td>
<td>Pass</td>
</tr>
<tr>
<td>4</td>
<td>Content Testing</td>
<td>Test additional content, such as cultural puzzles.</td>
<td>Complete puzzles or activities</td>
<td>Points or rewards accordingly</td>
<td>Pass</td>
</tr>
<tr>
<td>5</td>
<td>VR Quality Testing</td>
<td>Test graphics quality and VR experiences.</td>
<td>Interact with virtual environments</td>
<td>High-quality graphics</td>
<td>Pass</td>
</tr>
<tr>
<td>6</td>
<td>Sustainability Testing</td>
<td>Testing the environmental effects of sustainability.</td>
<td>Play over long periods</td>
<td>No performance issues</td>
<td>Pass</td>
</tr>
<tr>
<td>7</td>
<td>Error Testing</td>
<td>Test how the application handles errors.</td>
<td>Cause errors in interactions</td>
<td>The application gives the correct error message</td>
<td>Pass</td>
</tr>
</tbody>
</table>

This Blackbox testing table for virtual guiding applications includes tests to ensure the application functions properly and conforms to the expected functionality. The test results show that all tests have been successful (Pass), showing that the application can provide users with a good experience in interacting with virtual tour guides, exploring locations, completing additional content, and providing high graphics quality in VR experiences. This gives confidence that this virtual guiding application is ready to be used by users to explore and understand the culture and history of the Bacan and Ternate Palaces well.

**Conclusions**

Virtual guiding applications for the Bacan and Ternate Palaces, integration of SDLC methods, field data retrieval, and platforms such as Unity and Oculus Quest 2 have created an immersive cultural virtual tourism experience. In the future, this application is expected to bring users closer to history and culture interactively, with the potential to preserve and promote local cultural values. Further development will expand the scope to Tidore and Jailolo Palaces, as well as other historical attractions in North Maluku, focusing on deeper interactivity. In future development, the quality of graphics and interaction will be improved. At the same time, cooperation
with institutions and communities will expand the impact of these applications in the preservation and recognition of cultural and historical heritage. With a collaborative and innovative spirit, this virtual guiding application acts as a bridge that connects cultural heritage with modern technology. Developing a virtual guiding application for the Bacan and Ternate Palaces has taken us through a series of steps focusing on merging culture and technology. However, in order to advance this application and optimize its impact, several suggestions can be taken into consideration:

i. In-depth and Interactive Content: Further develop interactive content within the app. Integrating more diverse and engaging activities, such as cultural puzzles, simulated customs, or exploration of alternative routes, can provide users with a more memorable and immersive experience.

ii. Graphics Enhancement and Realism: Investing in improved graphics quality and realism of virtual environments can deliver a more immersive and engaging experience. The latest graphic and lighting development technologies can create more accurate and exciting environments.

iii. Multilingual Development: Consider providing multiple language options within the app so that users from different countries can better access and understand the content. This can support the app to become a more inclusive and global cultural learning tool.

iv. Sustainability Exploration: Use in-app technology to educate users about sustainability and environmental conservation. The educational content on conservation efforts and positive environmental impacts can provide an additional dimension to exploring cultural heritage.

v. Cooperation with Local Institutions: Develop closer cooperation with educational institutions, cultural organizations, and local governments. This can support field data retrieval, further research, and maintenance of more accurate content.

vi. Explore Other Attractions: After developing applications for the Bacan and Ternate Palaces, consider venturing into other historical attractions in North Maluku. Using the experience and learning gained, the application can bring users a more comprehensive cultural heritage.

vii. Development and Update Continuity: Do not stop at one point. Keep app development, improvements, and updates. Consider integrating new emerging technologies to provide a fresh and engaging experience for users.

By considering these suggestions, the development of this virtual guiding application has great potential to become an effective tool in introducing, preserving, and promoting culture and history in North Maluku. Continuous effort and commitment to development will have a more significant positive impact on preserving cultural and historical heritage for present and future generations.

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**Data Availability Statement:** The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

**Conflicts of Interest:** The authors declare no conflict of interest.

**References**


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