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Augmented Reality Portal Using Markerless Method at the Ergendang Cave Tourist Attraction

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ABSTRACT

For some visitors, natural tourism represents an attractive form of tourism in itself. One of the most notable natural attractions in North Sumatra is Ergendang Cave, situated in Penungkiren, Sinembah Tanjung Muda (STM) Hilir, Deli Serdang Regency. The promotional media for Ergendang Cave still exhibits deficiencies that impede its ability to attract local tourists. The utilisation of augmented reality (AR) technology has the potential to enhance the efficacy of promotional media by facilitating the creation of portal applications that integrate the virtual and tangible realms through markerless methodologies. This Android-based application has been constructed using the Unity 3D platform and the C# (sharp) programming language, in accordance with the prototype model SDLC system development method. This study presents information on the surrounding situation of Ergendang Cave tourism with 360° panoramic photos through a portal that aims to help attract tourists. The portal provides users with the ability to virtually visit the location in real time, effectively bridging the gap between the user's physical location and the virtual representation of Goa Ergendang Tourist Attractions. This could be particularly beneficial during the ongoing pandemic, as it offers a unique opportunity for tourists to virtually experience the attractions without the need for physical travel.

1. Introduction

Ergendang Cave is one of the natural tourist attractions in the Deli Serdang area which has the charm of the beauty of the cave and there is a hot spring pool which has good benefits for the body, this cannot be separated from the legend that Ergendang Cave was previously believed to be a special bathing place for the descendants of the king's daughters but it is not known what kind of kingdom is there in that area (Hidayah & Lubis, 2024), This tourist attraction is located in Penungkiren Village, Sinembah Tanjung Muda (STM) Hilir, Deli Serdang Regency. The name Ergendang is taken from the Karo language which means "beating the drum" which was discovered 8 years ago by Mr. Ingan Apul Sitepu as the owner of this tourist attraction, and was only managed around 2017.

Ergendang Cave represents one of the most notable natural tourist attractions in the Deli Serdang area. It boasts a distinctive charm and aesthetic appeal, complemented by the presence of a hot spring

pool that offers a range of beneficial physical effects. The cave's historical significance is further enhanced by the legend that it was once a revered bathing site for the descendants of the king's daughters. However, the identity of the kingdom that once flourished in this region remains shrouded in mystery. The tourist attraction is situated in Penungkiren Village, Sinembah Tanjung Muda Hilir, Deli Serdang Regency. The name 'Ergendang' is derived from the Karo language and translates to 'beating the drum'. This was first discovered by Mr. Ingan Apul Sitepu, the proprietor of the tourist attraction, eight years ago. It was only subsequently that management of the site commenced in 2017.

One of the current challenges facing the Ergondang Cave tourist attraction is the lack of awareness among the general public in North Sumatra. This is largely due to the absence of effective promotional media, which has resulted in a lack of optimal dissemination of information about the cave. The promotion of the cave is still carried out via word of mouth, online images, and websites that are not managed by the Ergendang Cave tourism management team. It can therefore be stated that the information conveyed about this tourist attraction is still lacking in interest. It is recommended that natural tourist attractions be developed with an effort to process static information into dynamic content, utilising technology to increase tourist attraction. The advent of virtual tourism has emerged as a notable alternative in the context of the current era, particularly in the wake of the global pandemic. The necessity to maintain minimal social interactions has underscored the potential of this digital avenue for fostering engagement (Sudipa et al., 2022). Virtual tourism represents a transformation in the adaptation to developments in the digital era and the changing patterns of modern living, particularly in the context of the pandemic (Cranmer et al., 2020; Triantafillidou & Lappas, 2022). It is a concept that utilises technology and offers a new approach to vacationing (Aditama et al., 2023; Wang et al., 2021).

At the present time, virtual tourism is being developed by a number of different parties, including the KEMENPAREKRAF. The results presented in this virtual tour are diverse, encompassing panoramic vistas of natural splendour, insights into cultural heritage, artistic performances, and a plethora of other experiences, all of which are available in the form of images or videos. The Ministry of Tourism and Creative Economy has developed the concept of virtual travel with 360-degree videos or photos via the official page "Indonesia.Travel". It is possible to undertake virtual tours of a number of Indonesian tourist destinations that have not previously been visited, including Banyuwangi, Bali, Jakarta, Yogyakarta, Wakatobi, Mount Bromo, Raja Ampat and many more (Maulana & Khansa, 2019). Consequently, efforts to enhance the natural tourist appeal of Ergandang Cave to a level commensurate with other natural tourist attractions may employ Augmented Reality (AR) technology, enabling tourists to engage in a virtual journey and simulate a first-hand experience through the Markerless Augmented Reality approach (Lubis et al., 2022; Oufqir et al., 2020).

The term "augmented reality" (AR) describes an environment in which the real and virtual worlds are integrated by a computer, creating a seamless blend between the two. This system is more closely aligned with the actual physical environment. In this system, the tangible reality is the primary focus. This system differs from Virtual Reality (VR), which is a fully virtual environment that entirely replaces the real world with a new virtual one. The utilisation of AR technology enables the real environment to interact in a digital (virtual) form. Similarly, data regarding objects and the surrounding environment can be incorporated into the AR system, which will then be displayed on the real-world screen in real time as if the information were actual. AR has considerable potential for application in industry and academic research (Shirley & Malathi, 2020). The utilisation of augmented reality technology in the context of industrial job skills training presents a multitude of notable advantages, including enhanced learning efficacy and elevated trainee engagement. Despite the challenges it currently faces, AR has the potential to transform the future of job skills training (Devagiri et al., 2022). In the academic field, the use of augmented reality in learning media has the advantage of being more engaging for learners and can be an effective means of enhancing the efficiency of learning processes (Dutta et al., 2022; Shirley & Malathi, 2020). Ali's research indicates a need for studies focusing on the development of students' cognitive abilities, including problem-solving, critical thinking, and analysis. These skills can be enhanced through the use of AR in learning field, offering insights into the cognitive benefits gained by students through this AR technology (Fitria, 2023).

The advent of the smartphone has had a profound impact on a multitude of fields. This is due to the fact that smartphones possess the requisite facilities to support further technological developments, thereby rendering work more complex. One of the most prevalent technologies on the contemporary

smartphone is augmented reality (AR). Similarly, Suyudi posited in his research that the rapid advancement of smartphones in 2021 has fostered a growing interest among Android users to possess the latest technological devices (Suyudi & Wafiah, 2023). Furthermore, the integration of AR Portal technology has the potential to enhance the virtual experience of tourists, creating a sense of presence and immersion in the desired tourist destination. This is analogous to offering a "try before you buy" experience, which can foster a desire to visit.

In consequence of the aforementioned explanation, the research project is designed to enhance the realism of the virtual tour, as this feature engenders a sense of immersion in the domain of tourism.In its application using the System Development Life Cycle (SDLC) system development method so that system development can be directed and measured in accordance with the stages of each process in the SDLC method.

2. Literature Review

The implementation of an augmented reality (AR) portal using a markerless method at the Ergendang Cave tourist attraction can significantly enhance the visitor experience by providing interactive and informative content. Augmented reality technology integrates digital information with the real world, allowing users to engage with their surroundings in innovative ways. This application can be particularly beneficial in promoting tourism by enriching the visitor's understanding of the site and its historical or cultural significance.

Markerless AR, which does not rely on physical markers for tracking, offers a flexible and user-friendly experience. This method allows users to interact with virtual content simply by pointing their smartphone cameras at the environment, making it ideal for outdoor settings like the Ergendang Cave. Research indicates that markerless AR can improve the accessibility of information and enhance the overall tourist experience by providing contextual data about the attractions without the need for additional physical markers (Affan et al., 2019; Bhaskara & Sugiarti, 2019; Fischer-Stabel et al., 2020). For instance, the use of natural features in the landscape as reference points can facilitate the seamless integration of AR content, as demonstrated in various studies (Yanti et al., 2024).

Moreover, the incorporation of AR in tourism has been shown to increase visitor engagement and satisfaction. Studies have highlighted that AR applications can deliver immersive experiences that cater to the emotional and aesthetic dimensions of tourism (Chen et al., 2021; Zhu et al., 2022). By providing 3D visualizations, videos, and interactive elements, the AR portal can help visitors better appreciate the geological and historical aspects of the Ergendang Cave, potentially leading to increased visitor retention and positive word-of-mouth promotion (Anwar et al., 2022).

Additionally, the economic implications of implementing AR technology in tourism are noteworthy. The integration of AR can attract a broader audience, including tech-savvy younger generations who seek novel experiences (Paiva et al., 2022). This aligns with the growing trend of utilizing technology to enhance cultural and heritage tourism, as evidenced by various successful implementations in different regions (Abdul-Jabbar, 2023).

The development of a markerless AR portal at the Ergendang Cave tourist attraction presents a promising opportunity to enhance visitor engagement, provide educational content, and promote the site effectively. By leveraging the capabilities of AR technology, the portal can transform the way tourists interact with the cave, ultimately contributing to a richer and more informative tourism experience.

3. Research Methods

Method of Collecting Data

The methods used in carrying out this research are (1) Observation, namely data collection techniques carried out by directly observing locations in the field and observing various things needed such as photo and video documentation which will be used as objects in this application; (2) Interview, namely a data collection technique by conducting direct questions and answers to sources who manage tourist attractions in depth to obtain accurate data; (3) Literature study, namely by studying various books and journals resulting from previous research related to this research so that they can be considered by researchers.

Software Development Methods

The system development method used is the System Development Life Cycle (SDLC) method using the Prototype model. The Prototype Method is a process that is carried out repeatedly until the desired results are achieved (iterative) in system development, where requirements are changed into a working system which is continuously improved through collaboration between users and analysts. This stage is carried out by determining the overall plan for creating the software (Riyanti et al., 2024; Rohman & Subarkah, 2024). The Prototype Method has several stages, namely gathering requirements, building a prototype, evaluating the prototype, coding the system, testing the system, evaluating the system and using the system. These stages can be seen in Figure 1.

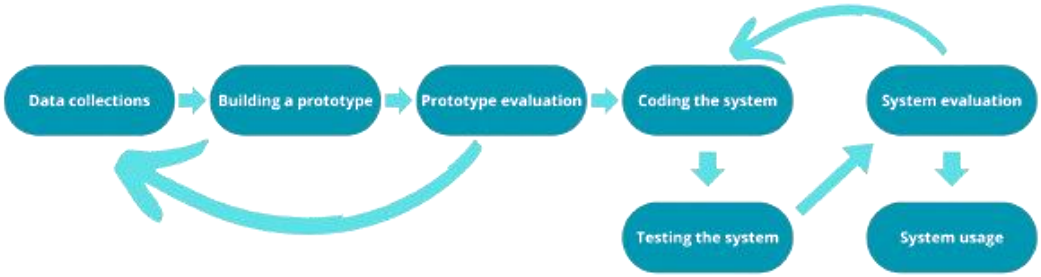

Fig. 1. Stages of The Prototype Method (Septiana & Septian, 2019)

In this research, the prototype method is used because it has sequential development stages to complete a software development and is easy to understand, so this prototype method is deemed suitable for use in this research. With this method, several stages are carried out to conduct research, namely, collecting the required data, system design, system evaluation, system coding, system testing and use of the system. In the first stage, collect the required data on the system for the application to be built. This stage is carried out by collecting data for system requirements so that it is easy to understand and meets the needs of the user. The next stage that will be carried out is design. In making the design for this Augmented Reality Portal application, use the draw.io web application to create a flow with UML and use Canva to create the application interface design which will be built in the next stage, namely evaluating the application designed to suit your needs, then coding the system to build it. application. Next, system testing is carried out using the black box testing method.

The AR method currently consists of two, namely Marker Based Tracking and Markerless. Both methods have their respective advantages and limitations, Marker Based is easier to implement and more accurate in tracking specific objects while Markerless AR is more flexible in terms of user location and is not limited by the need for physical markers. The choice between the two depends on the needs of the specific AR project and the environment in which the technology will be applied (Nugroho & Kalifia, 2023). The Augmented Reality Markerless method is currently very developed, with this method users can detect a wider variety of two or three dimensional objects without special markers. Markerless Augmented Reality has several models, namely, Face Tracking, 3D Object Tracking, GPS Based Tracking and Motion Tracking. This research applies a 3D Object Tracking model by detecting flat surfaces to reveal the Ergendang Cave Tourism Augmented Reality portal door object.

Application and Object Design

The process of modeling this application is carried out with UI and UX. In designing the initial design display for the Augmented Reality Portal application that will be built, the researcher used the Canva web application according to needs, then designed the UML (Unified Modeling Language) related to the application process flow using draw.io. The application use case can be seen in Figure 2.

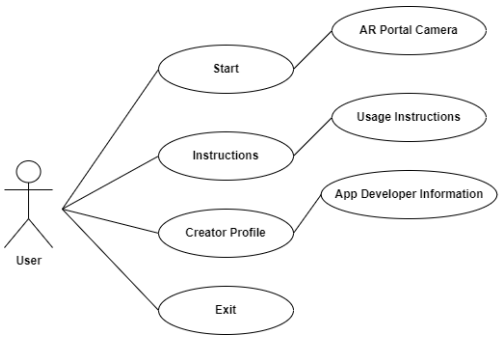

Fig. 2. Use Case Application Diagrams

For designing portal door objects and applications, they were built using the Unity game engine editor which contains several assets and a combination of program scripts to carry out each function. The Unity version used is 2018.3.1 with the C# (Sharp) programming language.

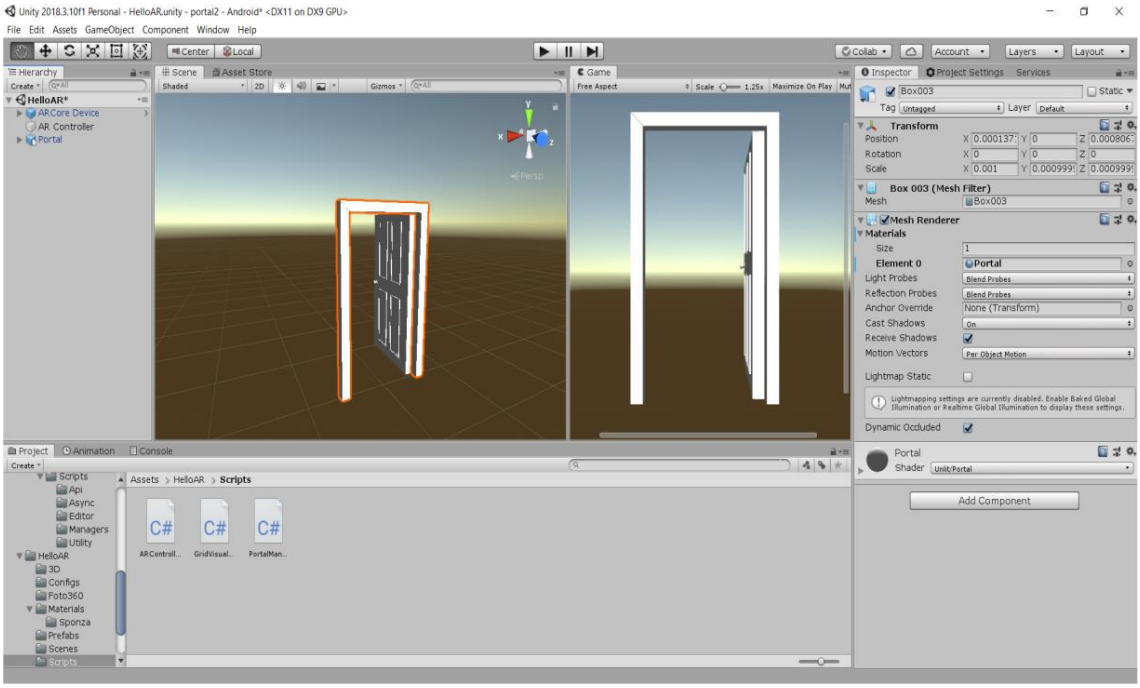

Fig. 3.Object Design Portals

4. Results and Discussions

Based on the application that was built, we obtained the results of combining virtual reality and augmented reality with a virtual tour concept for Ergendang Cave tourism. This application displays information about the state of the Ergendang Cave tourist environment, instructions for use and information about the application maker. So the results obtained are in the form of an Android-based application which functions to support and introduce tourist attractions, especially Ergendang Cave. The thing that needs to be shown before running this augmented reality portal application is that it meets the specifications requirements of certain Android devices with support for Google AR Core services and make sure you have installed this application on the Android device. The minimum specifications used in testing this application are SmartphonesSamsung Galaxy A51, ProcessorOcta-Core (2.3GHz, 1.7GHz), Android – One UI 4.1 (Android 12), 6.5 inch 1080 x 2400 (FHD+) Super AMOLED, RAM 6GB – 128GB and 48 megapixel rear camera (f/2.0, wide, PDAF).

Augmented Reality Portal Application Display

Main Menu Page Display

On the main menu page display there is the application title 'Ergendang Cave Tourist Attraction Augmented Reality Portal' and 4 buttons, consisting of the Start button, Instructions, Creator Profile, Exit.

Fig. 4. Main Menu Page View

Start Button Page View

After pressing the Start button, the camera display will automatically turn on and then bring up the augmented reality portal door in which there is a panorama of 3600 Ergendang Cave tourist attractions. Users can walk into the portal and can move their smartphone to see the existing panorama.

Fig. 5. Start View

Then the application automatically turns on the sound of a short explanation about Ergendang Cave accompanied by typical Tanah Karo music which can be heard while walking into the portal, and there is a Close button to end the game and then return to the Main Menu page.

View Entering the Panorama 3600 Portal

After the user walks slowly through the augmented reality portal door, the user can see a 3600 panorama of Ergendang Cave and the music and a brief explanation of Ergendang Cave automatically turn on.

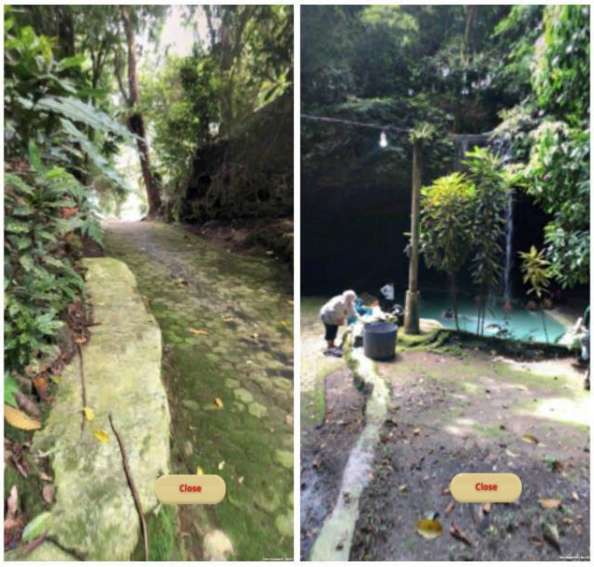

Fig. 6. Panoramic View of 360º Ergendang Cave

Portal View Looking Out

When the user walks from inside the portal and directs the camera to the exit of the augmented reality portal, the user will see the real world and there is a Close button to end the display and then return to the Main Menu page.

Fig. 7. Portal Exit Displays

Instructions Page View

After pressing the Instructions button, an explanation of how to use the application will be displayed which consists of several ways and there is a Close button to end the explanation display and then it will return to the Main Menu page.

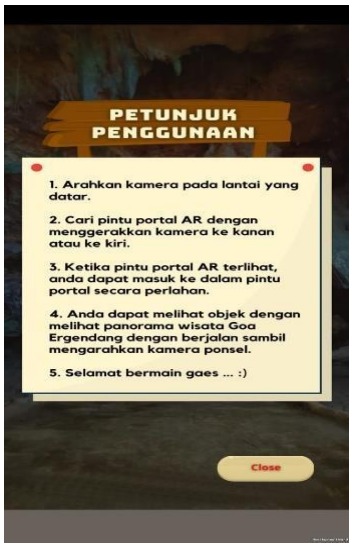

Fig. 8. Display of Application Instructions for Use

Creator Profile View

When you press the Creator Profile button, information will be displayed about the person who built the Ergondang Cave Tourism Augmented Reality Portal application and several media sources used. There is also an information display for the application creator which will close until it ends and then return to the Main Menu page.

Fig. 9. Application Maker Profile View

Exit Page View

On the Exit button there are two options 'YES' or 'NO' to ensure that the user really wants to exit or not from the application which raises the question "Want to Exit?".

Fig. 10. Exit Menu View

Black Box Testing

Black box testing is a system testing technique that aims to determine whether the function of the application is running as desired or not, whether the buttons on the application are working or not. The following is a table of black box testing results on the Ergendang Cave Tourism Augmented Reality Portal application which can be seen in the table 1.

Table 1. Black Box Testing

No	Scenes	Knob	Information	Results
1.	Start Menu		Button to go to the portal door page	Succeed
2.	Instructions Menu		Button to go to the page on how to use the application	Succeed
3.	Creator Profile Menu		Button to go to the application creator page	Succeed
4.	Exit Menu		Exit app button	Succeed
5.	Pop upGo out		warning before exiting the application	Succeed
6.	Exit Scene		Button to Return to the main menu page	Succeed

Testing was carried out for all the buttons contained in the Ergendang Cave Tourism Augmented Reality Portal application in table 1 to work well and function according to its function.

5. Conclusion

After testing and analyzing the Ergendang Cave Tourism Augmented Reality Portal application, the researchers concluded the research results were: (1). This Virtual Tour application was created using the Unity 3D editor utilizing Augmented Reality Technology and Google AR Core with the Markerless method; (2). This application displays information about the atmosphere of the Ergendang Cave tourist attraction with 3600 panoramic photos, information on application usage instructions, application developer information; (3). Only devices that can use this application have the AR Core feature; (4). Based on the results of this research, it is quite helpful for tourists to gain new experiences in exploring tourist attractions, especially Ergendang Cave. It is recommended that for further research, we can develop applications on operating systems other than Android. The following research can add new features such as educational games about tourist attractions, and the appearance of the application can be further developed to be even better.

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