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MR TOURGUIDE: A cultural adaptive mapping platform using mixed reality

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ABSTRACT

The recent advancements in virtual reality and augmented reality technologies have significantly enhanced the tourism sector by providing immersive experiences of various tourist destinations and heritage sites. This research introduces MR TOURGUIDE, a cultural adaptive mapping platform that uses mixed reality to create a comprehensive and interactive virtual environment. The platform utilizes cultural mapping to mobilize community collaboration through various strategies, building a knowledge base of integrated images, objects, and videos within a 360-degree virtual environment. In the COVID-19 pandemic, which has imposed severe restrictions and closures in the tourism industry, MR TOURGUIDE offers an innovative solution to preserve and promote cultural heritage remotely.

Keywords: virtual reality, augmented reality, cultural mapping, heritage sites, 360 virtual tours

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1. Introduction

Tourism is an important sector of the Philippine economy. In 2015, the travel and tourism industry contributed 10.6% to the country's GDP (Manila Bulletin, 2016). The Philippines is an archipelagic country composed of 7,641 islands, divided into 17 regions and 82 provinces. The country is known for having its rich biodiversity as its main tourist attraction (eTravel Pilipinas, 2009). Its beaches, heritage towns and monuments, mountains, rainforests, islands, and diving spots are among the country's most popular tourist destinations.

With COVID-19 afflicting the world, its effect on the tourism sector is worth mentioning. It is also believed that the tourism landscape will never be the same after the COVID-19 pandemic. Unless a vaccine is developed, the threat of another outbreak is always a possibility so safety will be the paramount concern of most of our visitors (tourism.gov.ph., 2020). Hence, the tourism industry needs to adopt stringent measures required to survive, thrive, and stay resilient under the new normal.

Many sectors are now migrating their business into various online platforms to reach more clients. Tourists can also enjoy the rich Philippine culture and arts from the comfort of their seats. Thus, the tourism sector can innovate and use technology in the delivery of its services. Attractions can be augmented to fill the gap between ICT innovations and different tourists.

Virtual reality (VR) allows the user freedom of choice, safety, identity, and privacy without coercion or deception. It provides a world that is enjoyable to see and interact with while eliminating dangerous or extraneous features or entities that might negatively impact the user experience. VR using 360 images and videos is mostly as realistic as possible while completely constraining user movement.

Through mixed reality (MR), people can virtually visit cultural and heritage sites from the comfort of their homes and away from health risks, particularly during the pandemic. It enables people with physical disabilities, financial constraints, or geographic limitations to virtually experience destinations they might not otherwise be able to visit. Post-pandemic, this platform can be used to visualize and simulate the original state of partially damaged sites to enhance appreciation and understanding of cultural heritage. MR can also allow tourists to experience a teaser of a destination, encouraging them to visit in person, which can help boost the tourism sector.

2. Materials and methods

To create a virtual environment, the researchers utilized an open-source 3D graphics software toolset (Figure 1).

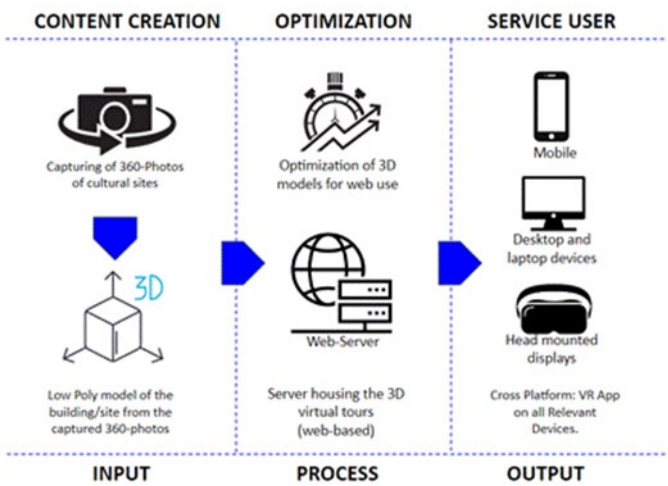

Figure 1. Methodology.

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The app generates an equirectangular photo, as shown in Figure 2, which will then be used as a virtual reality environment.

Figure 2. An equirectangular photo of a museum.

To create the full 3D virtual tour experience, the gathered data undergone the following processes: post-processing of 360-degree pictures, 3D projection, object augmentation, HTML importing, the addition of hotspots, historical information, background sounds, and narration auto tour setup.

The data was manually stitched from two fisheye captures using Adobe Photoshop, to create a seamless equirectangular image. The stitching process involved aligning the fisheye images based on control points and blending the overlapping regions to minimize visible seams. This process resulted in an equirectangular capture with a resolution of 5792x2896 pixels. To enhance the quality, Adobe Sensei AI's Super Resolution function was utilized, which employs advanced machine learning algorithms to analyze image details and interpolate additional pixels, effectively doubling the resolution to 11584x5792 pixels. The Super Resolution function adjusts for artifacts and enhances textures, ensuring sharper and more detailed outputs. This improved resolution allowed for more accurate projection of textures onto the walls in the 360-degree environment, as reflected in Figure 3. The combination of manual stitching and AI-driven resolution enhancement ensures high-quality results, though specific parameters, such as noise reduction and edge refinement, were adjusted to optimize the output quality and ensure the reproducibility of the method.

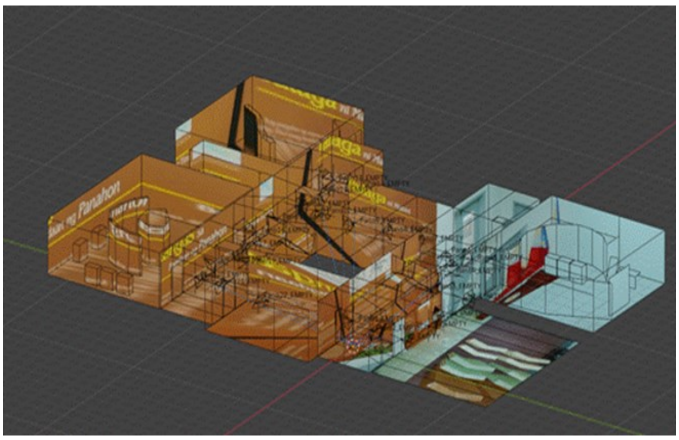

Figure 3. Photo of a low poly 3D model using camera projection.

After stitching, low-poly 3D models are created using camera projection techniques. Textures for each wall are derived from the projected 360-degree image shown in Figure 4. The 3D model is divided into multiple parts, each mapped with unique texture coordinates to ensure accurate alignment of the 360-degree image. The final model is exported in GL Transmission Format (glTF) to facilitate seamless integration into web environments.

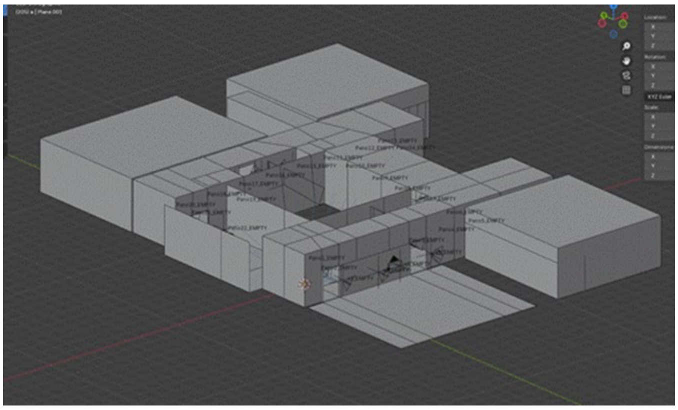

Figure 4. Poly 3D model.

Then, a combination of tools, including Adobe software for texture preparation, Blender 3D for modeling and UV mapping, and the Three.js JavaScript library for rendering were utilized. As shown in Figure 5, UV mapping is applied to one of the model parts, where the corresponding texture from the 360-degree image is baked into the UV layout. This ensures that textures are optimized for rendering and reduces unnecessary computation during runtime.

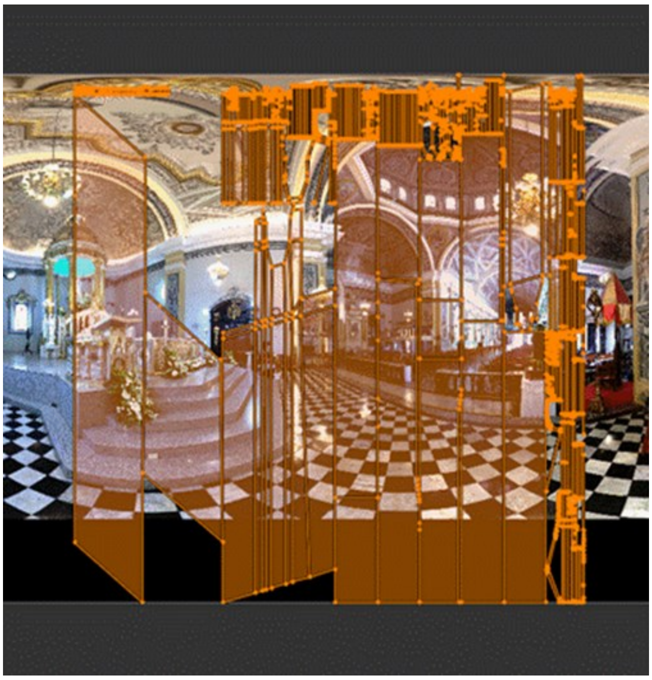

Figure 5. UV Map.

The baked textures are stored in a nested array, with each element representing a specific texture mapped to the 3D model. These textures, along with the glTF files, are integrated into a WebGL-based 3D environment for real-time rendering. Performance optimization strategies were implemented to ensure smooth interaction, including reducing texture sizes to balance visual quality and loading speed, simplifying the 3D geometry to minimize rendering times, and leveraging Three.js's efficient resource management features.

To enhance the user experience, a custom function was developed to enable smooth transitions between hotspots. As illustrated in Figure 6, when a user clicks on a hotspot, the camera smoothly moves to the corresponding hotspot position, minimizing latency and providing an immersive experience. The transition mechanism involves interpolating the camera's position and rotation using easing functions, while asynchronously loading the required texture for the selected hotspot to avoid frame drops. This ensures seamless navigation and reduces delays in rendering the updated scene.

Figure 6. Hotspot transition.

When the user clicks on the info spots shown in Figures 7 and 8, information about the heritage site, such as a brief history, is automatically generated and displayed on the screen. These info-spots are implemented using custom scripts in Three.js, through event listeners to detect user interactions. Each info-spot is represented as a 3D object within the scene, and raycasting is used to determine when a user's click intersects with an info-spot.

Figure 7. Info-spot.

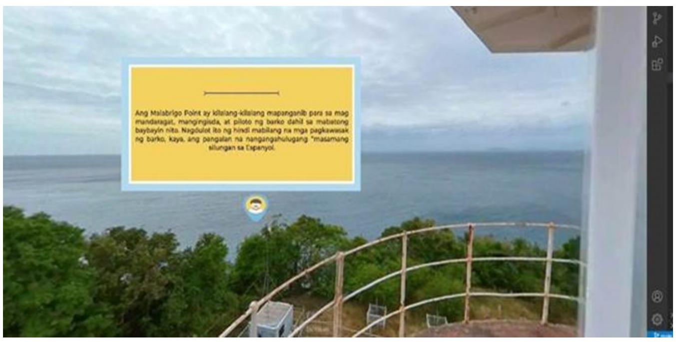

Figure 8. Augmented information.

Upon detecting a click event, the system retrieves the associated metadata for the selected info-spot from a predefined data structure and renders it in a UI overlay. To ensure smooth navigation, camera movements are programmed with Three.js easing functions, creating a natural transition to the corresponding hotspot or point of interest. The transitions use linear interpolation (LERP) for position and quaternion slerp for rotations, providing a fluid user experience.

Additionally, optimizations such as asynchronous data fetching are implemented to minimize latency when loading and displaying site information. This ensures that the interactive features remain responsive, and the navigation experience remains immersive, even in resource-constrained environments.

There is also an interactive map that the users could access to show the location of each heritage site that is available in the virtual tour (Figure 9).

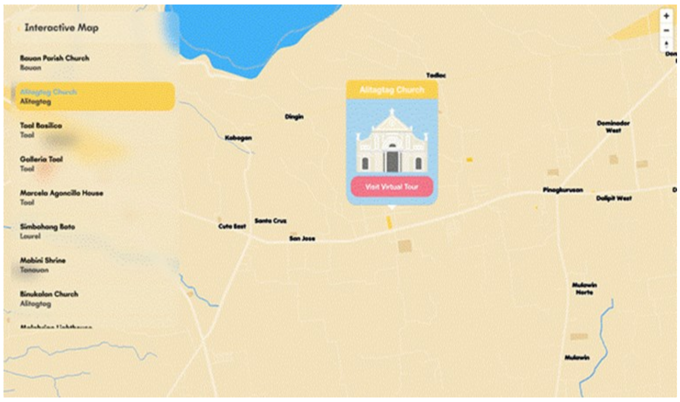

Figure 9. Interactive map.

Table 1 lists information about four different web browsers: Google Chrome, Microsoft Edge, Mozilla Firefox, and Safari. Each browser is listed with its key version number, VR/AR support, and memory usage.

Table 1. Cross Browser Testing.

Browser Category	Key version	VR/AR Support	Memory Usage
Google Chrome	Version 109.0.5414.120 (Official Build) (64-bit)	Yes	4700 MB
Microsoft Edge	Version 109.0.1518.69 (Official Build) (64-bit)	Yes	4700 MB
Mozilla Firefox	109.0 (64-bit)	Yes	4700 MB
Safari	Safari 5.1. 7	Yes	4700 MB

All four browsers listed in Table 1 have VR/AR support, as indicated by the "Yes" in the VR/AR Support column. Google Chrome and Microsoft Edge are both based on the Chromium browser engine and are both 64-bit versions. Mozilla Firefox is also a 64-bit browser. Safari, on the other hand, is Apple's proprietary browser, which is only available on Apple devices.

In terms of version numbers, Google Chrome is the most up-to-date browser listed in Table 4, with the latest official build. Microsoft Edge is also a relatively recent version, but its version number is not as high as Google Chrome's. Mozilla Firefox's version number is less specific and does not indicate whether it is an official build or not. Finally, Safari 5.1.7 is an older version of the browser and may not have the same features or security updates compared to recent versions.

Additionally, all four browsers use 4700 MB of memory, which is a relatively high amount. With this required memory usage, users with low-end devices can experience performance issues such as slow loading times, application crashes, or platform instability. Additionally, prolonged high memory usage may cause overheating and battery drainage on mobile devices.

To validate the user experience of the platform, the researchers created an instrument that gathered insights on the platform's attractiveness, ease of use, stimulation, and innovativeness. The researchers used a descriptive method in analyzing and interpreting the data gathered through survey questionnaires. Descriptive research aims to accurately and thoroughly describe a population, situation, or phenomenon.

The respondents are the representatives from private and public institutions who attended the validation phase of the project. The study used researcher-made questionnaires to determine the user's experience of the application. Scales of 1 to 4 were used to determine the level of user's experience with 1 for user with the lowest experience and 4 with the highest experience. Moreover, the mean and composite mean were used as statistical tools to determine the experience of the respondents with the technology.

The validation was carried out using the user's experience in terms of the virtual tour's attractiveness, ease of use, stimulation, and innovativeness. Attractiveness is the overall impression of the product, the degree of likeness, and the disagreement of the user with the product.

Figure 10 shows that the majority of the respondents had a positive experience with a composite mean of 3.56 and found it to be enjoyable. The high number of participants who voted for "strongly agree" further emphasizes this positive experience.

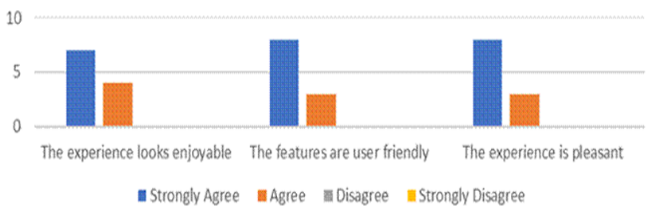

Figure 10. Attractiveness of the product.

Ease of use is the familiarity with the product and easiness of the use of the product. Figure 11 shows that the majority of the respondents found it easy to learn and use with a composite mean of 3.65. The high number of participants who voted for "strongly agree" further emphasizes the product's ease of use.

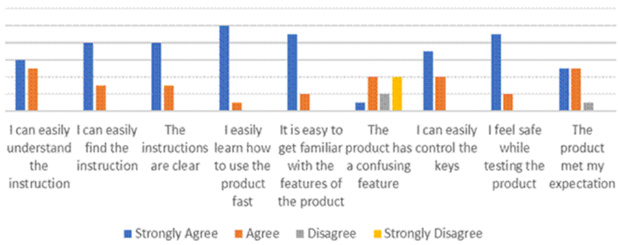

Figure 11. Ease of use of the product.

Stimulation is measured by the excitement of the user to the product. Figure 12 shows that the majority of the respondents found it to be interesting and exciting with a composite mean of 3.88. The high number of participants who voted for "strongly agree" further emphasizes this positive experience.

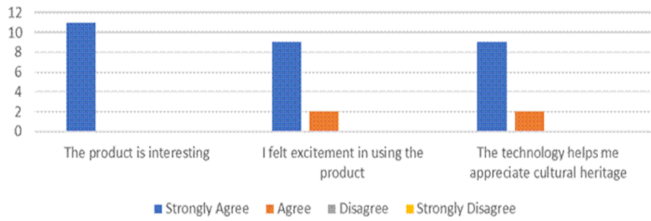

Figure 12. Stimulation of the product.

Figure 13 shows that the majority of the respondents found it to be innovative and remarkable with a composite mean of 3.67.

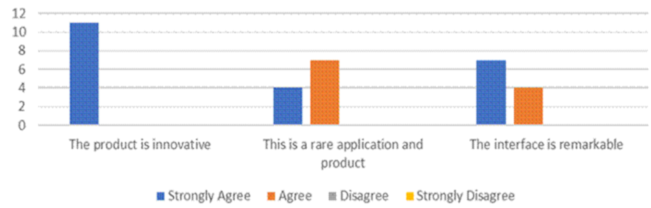

Figure 13. Innovativeness of the product.

4. Conclusion

Based on the results and discussion, all four web browsers—Google Chrome, Microsoft Edge, Mozilla Firefox, and Safari—provide VR/AR support and exhibit a consistent high memory usage of 4700 MB, which shows that any of these is a good browser for MR TOURGUIDE. This suggests that regardless of the browser chosen, users can expect a similar level of support for virtual and augmented reality technologies. However, the high memory usage across all browsers may be a concern for users with limited system resources.

The survey data strongly suggests that the respondents perceive MR TOURGUIDE as highly attractive. It provides an intuitive and accessible user experience, which is crucial for customer satisfaction and can contribute to its overall success in the target market. MR TOURGUIDE also provides an engaging and stimulating user experience and offers novel and creative features, which can make it stand out in the market and attract users who value innovation.

Acknowledgment

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