



# Interactive Spatial Augmented Reality Book on Cultural Heritage of Myanmar

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## Abstract

Myanmar, also called Burma has rich cultural heritage and historical tourist attractions are yet well known to the world. Therefore, we design and develop an interactive Spatial Augmented Reality (iSAR) book on cultural heritage of Myanmar. This iSAR book has total of 18 pages with rich media contents like videos, animations, audio and images to features cultural heritage of Myanmar in a digital format. Besides the virtual contents, navigational features like virtual buttons and touch-based hand gestures had been implemented using Leap Motion and VVVV. Therefore, iSAR book allows virtual contents and navigational features merges into the physical book seamlessly. Five (5) volunteer participants were recruited to evaluate the prototype of iSAR book and interviews are conducted to gather their feedback based on the immersive of the iSAR book. Thus, iSAR book of Myanmar is able to share the cultural heritage of Myanmar, and ultimately immerses the users to explore and gain more insights about the Myanmar cultural heritage.

**Index Terms:** Cultural Heritage, Interactive, Projection Mapping, Spatial Augmented Reality.

## I. INTRODUCTION

Museums and cultural exhibits play an important role in show case and preserving the country's cultural heritage. However, museums and cultural exhibits fail to attract visitors and there has been a drop of interest from public due to technology advance that could retrieve information instantly without visiting the museum. Instead of passive buildings simply storing and exhibit objects in the museum, with the advancement of technology, museum can transform and have an active role in sharing new knowledge such as creating a platform with entertaining education for all

children, and a trusted source of information or learning for all adults. Modern approaches involving technologies such as Spatial Augmented Reality (SAR) using projection mapping are being implemented in developed countries (eg. in the National Museum Zurich) [1] to recapture the interests of the public. However, less developed countries like Myanmar have yet to implement such technologies. This paper presents an interactive Spatial Augmented Reality (iSAR) book as solution to offer entertaining education platform for all public to learn about the cultural heritage of Myanmar and indirectly promoting economic growth through tourism.

SAR has become popular and high potential for enhancing

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the multiple users experience and interaction of virtual contents through the real world without wearable devices such as hand-held or head-mounted display [2, 3]. Due to the advantages of SAR, there are various of application fields like industrial design, education, art and entertainment applications has adopted this technology widely [4]. SAR is usually carried out using projection mapping techniques by superimposing the virtual contents on the real world through a projector creating the illusion as if it is part of real world. This approach is limited to stationary uses and offers a more immersive and authentic user experience. Projection mapping by itself does not allow for user interaction, as it only projects pre-defined videos or images on to the object. In order to improve user interactions, we use navigational features like virtual buttons and touch-based hand gestures as modalities that allow multiple users to interact with the virtual contents on the physical book.

## II. LITERATURE REVIEW

Technology advancement has motivated researchers to design and create new form of cultural heritage knowledge for public to learn. There is a collective of interactive projection mapping applications available and the works are summarized in section A. In order to improve the engagement of multiple users, there is various of modalities and projection mapping toolkits and/or SDKs are available to design and support interaction. Review of input modalities are presented in section B and section C summaries the projection mapping toolkits and SDKs for SAR.

### A. Related Work

The interactive books developed by iart [5] that exhibit on Paul Gauguin at the Foundation Beyeler has motivated museums and cultural exhibit to use the book framework widely to convey the information through the physical book which is painted via lights (projection mapping), the contents are tangible (interactive), and support user with rich media via interaction. This framework offers new platform and experience for museum visitors to learn about the cultural heritage and attracts many new visitors as it provides a new and fresh experience to introduce the ancient world via technology. Table 1 compares media content of seven related work [1, 6 – 11] that aid in the dissemination and education of cultural heritages. Types of media to support the virtual contents are 3D models, images, animations, video, and audio. 3D models are mainly used in 3D projection mapping applications where the virtual contents are projected onto a 3D real world object [6, 10, 11] for enhancing user experience with realistic effect. Most of the SAR application, has at least of two types of media in cooperated to design and develop the virtual contents.

**Table 1.** Comparison media usage on various projection mapping applications related to cultural heritage

Author(s)	3D Models	Images	Animation	Video	Audio
[1]	x	✓	✓	✓	✓
[6]	✓	x	✓	x	x
[7]	x	x	x	✓	✓
[8]	x	x	✓	x	✓
[9]	x	✓	✓	x	✓
[10]	✓	x	✓	✓	✓
[11]	✓	x	✓	x	x

### B. Input Modalities

**Table 2.** Comparison of various input modalities for interactive projection mapping or iSAR application

Input Modal	Sensing Capability	Gesture Recognition	Usable Range (from sensor)	Accuracy
Touch Screen	Touch, Depth	Possible	Must touch screen	High
2D Web Cam	Presence, Colour	Possible	0.3m to 1.6m	Low
Microsoft Kinect	Distance, Touch	Possible	0.8m to 3.5m ~57.5 degrees of horizontal view ~43.5 degrees of vertical view -27 to +27 tilt	Medium
Leap Motion	Distance, Touch	Possible	1 to 20 inches 150 degree field of view	Medium – High
Touch Board	Distance, Touch	Impossible	Either touch or proximity 0 to 5 inches	High

SAR applications require interactivity for offering dynamic contents to support the entertaining education of cultural heritage. The common interactive features are virtual buttons, hand gestures and the use of dynamic pages such as fiducial marker tracking for user to interact with the real object or virtual content. There are various input modalities in iSAR application that offers interactivity. Table 2 shows the comparison of the

various input modalities features and capability for researcher to opt in designing the iSAR application.

Limitation of the normal 2D web camera does not support depth information, which greatly impacts the accuracy of the 3D tracking. Therefore, it faces challenges to differentiate various hand gestures such as a hover and tap as selection. Thus, 3D cameras are getting popular such as Microsoft Kinect [12-13] and Leap Motion [14]. The Microsoft Kinect and Leap Motion offer reasonable features and capability to use in designing and implementing iSAR application. However, Microsoft Kinect official drivers of Kinect version 1 does not offer tracking the individual finger movements rather it only tracks the movement of the entire hand. This resulted in a larger trigger area for the physical book. Leap Motion device was tested and it allows tracking of individual fingers and offers more accurate precisions in a smaller area. As for touch board [15] which uses conductive ink to form and use it as input capture method when touched or in its proximity. Thus, using this touch board would require the conductive ink to be painted on the various areas on the book for triggering the interaction.

### C. Toolkits and SDKs for iSAR

The development of iSAR introduces a number of projection mapping toolkits and interactive SDKs such as Lumoplay [16], PapARt: Paper Augmented Reality (AR) Toolkit [17], VVVV [18], TouchDesigner [19] and OpenFrameWorks [20].

Lumoplay is a platform for developing interactive experiences with projections or touchscreens. For projections it supports inputs from touchscreen, a normal 2D webcam or 3D cameras such as the Microsoft Kinect. It is commonly used for games or for marketing purposes. The application provides manual calibration for the projector location, by manually clicking on the edges of the display covered by the projector. However, since this is designed for simple plug and play use and targeted to the general public the features are very limited and basic.

PapARt is a software development kit (SDK) for the development of interactive projection mapping and AR applications. For normal AR applications a normal webcam can be used however, for interactive projection mapping application, a depth camera for object and hand tracking is required as well as a projector to project on to the surface. The cameras are pre-calibrated using intrinsic parameters to enable extrinsic calibration based on how the cameras are located from one to the other. PapARt uses ARToolkit and OpenCV as its tracking libraries. PapARt also calibrates the projector to enable the projection mapping. PapARt is built as a processing library. It is a programming language and Integrated Developing Environment (IDE) for creative programmers. It is open source and free to use.

VVVV is a general-purpose toolkit with a special focus on real-time video synthesis and programming large media environments with physical interfaces, real-time motion graphics, audio and video. It is an open source program that relies on the community's contributions based on add-ons. It is an ever-growing platform and acts as a hub suitable for various projects involving motion graphics, projection mapping, computer vision, and others. TouchDesigner is a visual development platform that provides the tools to create real-time projects and rich user experiences. It is suitable for creating interactive media systems, architectural projections, live music visuals. OpenFrameWorks is an open source tool kit created for creative coding. It makes the development process easier by wrapping the common necessary tools such as OpenGL, GLEW, GLUT, libtess2 and cairo for graphics, rtAudio, PortAudio, OpenAL and Kiss FFT or FMOD for audio input, output and analysis, FreeType for fonts, FreeImage for image saving and loading, Quicktime, GStreamer and videoInput for video playback and grabbing, Poco for a variety of utilities, OpenCV for computer vision, Assimp for 3D model loading.

## III. iSAR BOOK of MYANMAR

### A. iSAR Book Design and Setup

iSAR book uses a 2D flat surface of a book page, the 3D models were made interactive, by allowing the user to rotate the view of the 3D model. Furthermore, the user can also control the directional lighting of the 3D model scene by swiping their finger left and right. The iSAR book application contains an image gallery, videos, 3D model, audio and animation to provide an immersive user experience which an ordinary book cannot offer. Furthermore, the videos, audio and images are dynamic and can be controlled and triggered by the user through virtual buttons. Lastly, 360-degree images were added with user control through hand gestures.

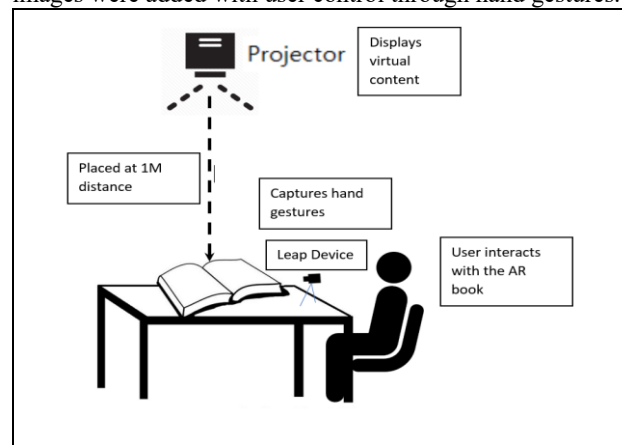
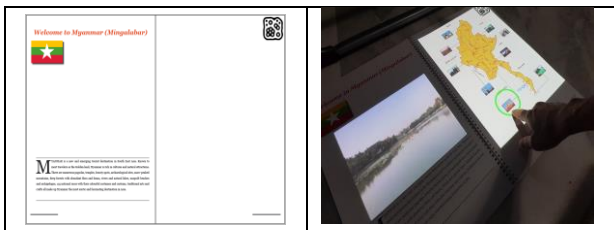


Fig. 1. Environment setup iSAR book for cultural heritage of Myanmar

A major aspect of the project was the tracking of the hands and fingers to enable the book to act as a “touchscreen” and for the projections to respond dynamically to these hand movements. The leap motion is placed between the user and the book. It is facing the book so when the user’s finger is within its tracking range, it will return the finger coordinates to VVVV. Fig. 1 shows the sketch setup of the environment for iSAR book, Leap device and projector. Therefore, the iSAR application supports direct interaction between the user and the book unlike in the case of ISO CAM [6] in the literature review which uses a touch sensitive table to indirectly control the projection.

## B. Interaction on Physical iSAR Book

The design of the physical iSAR book acted as a key component in this project as the virtual contents were projected on to it to complement the iSAR book. These projected areas were left blank to enable dynamic contents to reflect the cultural heritage of Myanmar. The book was designed through sketches and using Adobe InDesign. The iSAR physical book contains text and images. The fiducial trackers are detected by reacTIVision which is a computer vision framework. The AR application displays the animation and video virtual content through the projector. Furthermore, sound and music are played through the AR application. Leap sensor is used to capture hand gestures through the Leap SDK.



**Fig. 2.** Example of page 2 and page 3 of the physical iSAR book of cultural heritage, Myanmar

Fig. 2 on left illustrates the actual page 2 and page 3 of iSAR physical book with text and image as static information on page 2, while the blank page on page 3 is the area where a virtual map of Myanmar with the points of cultural interests is projected. Fiducial trackers are printed on the top right-hand side of each pair of pages as marker. The user’s hand movements are tracked using the Leap Motion sensor and when a user touches a cultural interest point, a video about the cultural interest site will play on the opposite page 2 of the blank area. The page 3 displays a map with hotspots that can be triggered when pressed. When the hotspots are triggered, related videos of the triggered place of interest will be played on the opposing second page. Fig. 2 on right shows the integration of virtual contents into physical iSAR book

where user using finger point to trigger the culture attraction and video is superimposing on the page 2.

The same design concept is applied on the remaining pages according to the order of storyline of the cultural heritage of Myanmar. The page 4 and page 5 showcase the six (6) groups of Myanmar traditional instruments when a user presses on one of the instruments in page 5, the sound of the relevant instrument is played. The musical notes jump based on the tune of the song. The animated notes are projected onto the printed lines of the empty musical sheet, to allow for a seamless integration of the virtual and real-world content. On the page 4, a video of a puppet show was also added. However, the sound is muted to avoid interruption when a user presses a musical instrument on page 5. The page 6 and page 7 showcase the world’s largest book and the Kuthodaw pagoda. A video of the Kuthodaw pagoda is automatically played on page 7 once it is flipped. The ancient city of Bagan is showcased on page 8 and page 9 where a 3D model of the Khayiminga temple interior was downloaded from SketchFab [20].

The page 10 and page 11 showcase the wondrous highlights of Myanmar through a printed image gallery on the page 10 and a virtually projected image gallery on the page 11. The virtual image gallery contains virtual buttons that can be triggered to view the enlarged image as well its relevant text. Both the enlarged image and text are dynamic. The popular Myanmar delicacies are highlighted on page 12 and page 13. On the page 13, two videos about Jaggery are being played. However, only one is made audible. It also contains virtual texts about Jaggery. The 360-degree image extends on pages 14 to 15 to showcase the Mandalay Palace to allow for a wider viewing experience. Furthermore, the user can use the hold and drag gesture to rotate the view. By tapping on the arrows on the ground the user can travel to the next near 360-degree image available in the area, similarly to Google Maps street view. The final two pages (16, 17) showcase an overview of The Golden Land, iSAR Book. The book cover is displayed on the scene and when the user touches the book, it opens up playing an overview video of the book.

## IV. DISCUSSION AND CONCLUSION

### A. Environment Setup

The design of the environment space plays an important factor in this iSAR book. As the target environment is in public exhibition and/or museum, the projector and the Leap motion device are to be in stationary setup. From the experiment setup, Leap motion device is placed at 55cm from

the starting top edge of the book after testing to maintain the finger tracking. However, it was found that the coordinates values shifted when the finger is further from the Leap motion device. In order to allow the Leap sensor to effectively detect and track a user's finger when it is touching the book, the Leap sensor was elevated from the ground at 9cm. Similarly, the placement of the projector was also important as the projections should not be obstructed by the user who is interacting with the book. Therefore, the projector is mounted at top, it is 1meter distance from the AR book. The webcam is mounted at a height of 30 cm from the surface of the book, focusing on the Fiducial markers.

## B. VVVV challenges on 3D Models

Loading the 3D models with textures proved to be a challenge as there is a limit on texture size in the 32bit VVVV. The 64bit VVVV could not be used as it did not support for fiducial trackers. Therefore, the original 3D model downloaded from sketchfab had to be resized from 8192x8192 to 4096x4096. The 3D model was then loaded in Blender to retexture and map the new resized texture onto it. It was then exported as a collada file(.dae) to be loaded in VVVV. The 3D model is loaded into VVVV using the ColladaFile node into the Mesh node which returns mesh and the FileTexture into PhongDirectional node. This is then grouped together with the axis node which displays the directional arrows of the axis to be displayed in the renderer.

Another challenge was in controlling the view of the 3D model, as mapping the leap input values directly into the camera view matrix of the Camera (Transform Orbit) node proved to be inaccurate. Therefore, the cursor (System) node was applied to impersonate a mouse cursor. The x and y outputs of the leap tracking patch was mapped into the x and y coordinates of the cursor (System) node and the Z bang output was used to impersonate a left click.

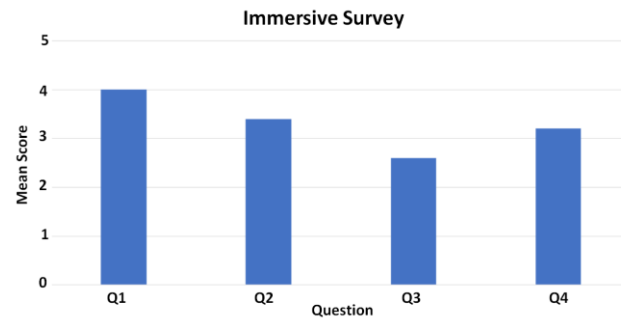
To control the directional lighting based on the user's hand movements, a Light (Directional) node was added into the PhongDirectional. The x output from leap tracking patch was set as the input for the yaw rotation of this Light (Directional) node. However, if the user's finger is not currently present in the scene the model will be pitch black as the yaw value of the Lighting (Directional) node will be null as the finger is not currently detected. Therefore, an AvoidNIL node was added to provide a default value if the LeapTracking patch provides a null output for the x axis. Furthermore, a Damper (animation) node was added to slow down the changing of the yaw rotation value. This allowed for a fading light animation effect.

## C. Immersive Evaluation

The system testing and users' feedback on usability [22] showed evidence that the projection mapping application and the physical AR book were interactive and fully functional. This work is further evaluated on the immersion of the virtual contents on the physical book. User testing is conducted to gather valuable feedback on immersion of iSAR book. In this user testing, five (5) volunteer participants were recruited and asked to explore the iSAR book application. They were allowed the freedom to explore and learn about Myanmar through the iSAR book. In order to test the feeling of immersion from users, the participants are asked to rate their answers accordingly on the Likert scale of 1 (strongly disagree) to 5 (strongly agree).

**Table 3.** Questions for immersion evaluation

No	Question
Q1	Was watching the virtual contents just as natural as watching the real word?
Q2	Did you have the impression that the virtual contents belonged to the real book (Physical book)?
Q3	Did you have the impression that you could have touched and grasped the virtual contents?
Q4	Did you pay attention at all to the difference between real and virtual contents?



**Fig. 3.** Mean score for immersion survey of 5 participants

The questions prepared in Table 3 had been modified from Regenbrecht and Schubert [23] to better fit the current context and Fig. 3 shows the mean score for each question. Although findings from Q1 and Q2 towards the agreement of where majority of the participants seems to be immersive with the virtual contents, however Q3 and Q4 shows that sense of tangible still need to be improved, and minimize the attention of user to differencing the real and virtual content.

## D. Conclusion

The current interactive projection mapping application can be further improved by using a higher resolution projector with higher lumens. This will greatly improve the visual quality of projected virtual contents. Furthermore, the use of a rear projection projector will reduce the effect of shadows being casted by the user's hands onto the AR book. In summary, the interactive projection mapping application on iSAR book was found to be effective to enhance the cultural heritage of Myanmar whilst providing an interactive and immersive experience to the users.

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