Project Plan

AR-Driven Exhibit Interaction: A Prototype for Enriched Displays

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Glossary

augmented reality Is the technology that creates an environment where users are able to see the real world overlaid or combined with virtual object with information related to the real world context [1, 2]. 3

extended reality Is the umbrella term for virtual reality (VR), augmented reality (AR), mixed reality (MR), and any other reality on Milgram's [3] reality-virtuality continuum [4]. 4

galleries, libraries, archives, and museums Is any cultural institutions, mainly galleries, libraries, archives, museums, that provide public access to knowledge and maintain cultural heritage. 3

optical see-through Is the a type of XR head-mounted device that uses a virtual reality display where the virtual environment displayed is replaced by the live feed of the real world environment [5, 6]. 10

video pass-through Is the a type of XR head-mounted device with a see-through display made by transparent mirrors and lens where the overlaid virtual object are displayed on [3, 6]. 10

virtual reality Is the technology that allows the users to be immersed in a completely virtual environment [3]. 7

Acronyms

AR augmented reality. 3, 5, 7, 9, 10

GLAM galleries, libraries, archives, and museums. 3–5, 7, 9

VR virtual reality. 7

XR extended reality. 4, 5, 9

Figure 1: An example of traditional physical exhibits the National Museum of American History Source: `https://www.flickr.com/photos/nationalmuseumofamericanhistory/4408830200`

1 Project Background

In recent years, the rapid evolution of augmented reality (AR) technology, such as the introduction of new AR able headsets, such as Meta Quest Pro and Microsoft HoloLens, and the improvement of AR application on mobile device, has transformed the landscape of immersive experiences. This technological leap has expanded the horizons of AR applications beyond the realms of entertainment and business, ushering in new possibilities across various domains.

In parallel, the traditional physical exhibits in galleries, libraries, archives, and museums (GLAM) as seen in Figure 1 have certain limitations. These conventional exhibits often lack interactivity, which leaves visitors with a passive, single-dimensional experience. Additionally, physical space often limits the capacity to provide in-depth information and engagement, resulting in visitor disengagement and diminished learning experience.

This project seeks to bridge the gap between the boundless potential of AR technology and the need for enhanced interactivity and information display within GLAMs. By leveraging AR advancements, we aim to create immersive and interactive AR applications that enrich the visitor experience, transform how information is presented, ultimately elevate the educational result of those institutions.

2 Related Studies and Existing Applications

2.1 Interactivity, Engagement, and GLAM Exhibits

GLAMs, especially museums, have always played a significant role in providing learning opportunities outside our formal schooling system [7]. Therefore, engagement is a crucial factor in fulfilling these goals to attract visitors to visit these institutions and have an effective learning experience.

Witcomb [8] suggested that interactive exhibits are considered more entertaining than traditional exhibits and thus can increase engagement and visitor interest. This might be because the more interactive element an exhibit has, the longer the time visitors will spend on it [9], which is shown in the result of the average staying time of visitors increase from 13.8 to 23.8 seconds when they can manually manipulate exhibit component from the study conducted by [10].

Other than making GLAMs more appeal to visitors, engagement through interactivity also provides an environment for active learning [11]. According to [7], interactive exhibits allow visitors to actively participate, determine what content is presented, and narrate their own experiences, such as letting visitors decide the order and detail level of the exhibit's information they consume. In which these kinds of interactive engagement overlap with features of an active learning experience [7].

2.2 Interactive Technologies in GLAMs Other than XR

Before and even after extended reality (XR) technology has matured to the current state, other interactive technologies, including information kiosks, tabletop displays, and video game stations, are used for interactive exhibits in GLAM.

During the 2000s, information kiosks (see Figure 2) were one of the primary devices used to bring interactivity to exhibits. They are screens with either a touch screen or buttons placed alongside exhibits that provide different information, such as videos about the exhibited object's production and operation, descriptions of its texture, and relevant diagrams [12]. However, an issue with information kiosks is that visitors may spend more time with it than the exhibited object [13], which may cause it to contradict the purpose of interactive exhibits.

On the other hand, tabletop displays (see Figure 3) and video game stations (see Figure 4) are two other commonly used interactive technologies for GLAMs. Tabletop displays are horizontal

Figure 2: An example of information kiosk for exhibits in the National Library of New Zealand
Source: `https://www.tepunafoundation.org.nz/campaigns-news`

workspace surfaces where hand gestures or everyday objects, such as mouse or mouse-like objects and RFID-tagged paper, are used to manipulate information to mimic how people interact with their surroundings in daily life [14]. Video game stations in GLAM are equipped with serious video games that combines video game with the aspect of learning and thus provide both education and entertainment values [15]. Although both technologies provide great interactivity, they are usually not related to a specific exhibit and are here to summarize the entire exhibition.

2.3 Why should AR be used for GLAM Exhibits?

The nature of XR, especially AR, fulfills the requirement of interactivity and can lead to the increase in essential engagement factor of GLAM exhibits mentioned in Session 2.1. AR embodies an audio-visual display and graphical interface [16, 17]. According to Pujol and Economou [18], the graphics presented in the XR environment and its graphical interface are suitable for learning abstract, dynamic, and non-intuitive ideas, which are the nature of the information that GLAM exhibits bring out. Besides, AR technologies' having audio-visual display allows it to fulfill the role of an information kiosk.

Additionally, the overlay content is another feature of AR that facilitated engagement and learning for GLAM exhibits. As AR can overlay virtual information while able to view the physical

Figure 3: An example of tabletop display in the Indianapolis Museum of Art
Source: [14]

Figure 4: An example of video game stations in the Swedish National Museum of Science and Technology
Source: `https://commons.wikimedia.org/wiki/File:Video_games_-_Tekniska_museet_-_Stockholm,_Sweden_-_DSC01675.JPG`

exhibits object and the exhibition spacial layout, it allows a bidirectional communication of the content in both the AR space and the real world and thus preserves the traditional relationships between the space, object, information, and the visitor [18, 19]. These traditional relationships can allow visitors to move in the exhibition space and concentrate on both the information and the exhibited object [18, 20], overcoming the downsides of the information kiosk.

2.4 Existing AR Application in GLAMs

Currently, many GLAMs, mainly museums, are adopting AR mobile application to improve their engagement. For example, the "Skin and Bones" app developed by the Smithsonian National Museum of Natural History is for the "Bone Hall" exhibition with the skeletons of every major group of vertebrate animal [21]. The app uses image tracking to overlay images and animations of how the animals move and look when alive (see Figure 6). The visitors' responses were very positive, and the time they stayed in the "Bone Hall" exhibition increased from 1:34 min to 14:00 min after the app was launched [22].

Another AR app is the "Chicago00 Eastland Disaster" app from "The Chicago 00 Project" launched by the Chicago History Museum. This project used both AR and virtual reality (VR) to showcase the museum's film, photo, and sound archive about Chicago stories, in which this app reassembles the disaster in Chicago with the single most significant number of death [23]. The app uses AR to overlay historical photographs and newsreel films to the real-world location where the disaster happened (see Figure 5).

Finally, the "ArtLens App" for the "ArtLens Gallery" in The Cleveland Museum of Art, an interactive exhibition filled with interactive exhibits and installation. The app is an overall guiding app for the exhibition, and one of the major features is using image recognition to recognize a selection of 2D and 3D artwork and provide curatorial and interpretive information [24]. For 2D artwork, the additional content is located according to the artwork using image tracking (see Figure 7).

3 Objectives

In response to the needs that may not be able to fulfill existing research and products on AR applications for GLAM exhibits, our project hopes to develop a AR interactive interface that

Figure 5: Screenshot of the "Chicago00 Eastland Disaster" app
Source: `https://play.google.com/store/apps/details?id=org.chicago00.eastland`

Figure 6: A scene of how the "Skin and Bones" app work
Source: `https://naturalhistory.si.edu/exhibits/bone-hall`

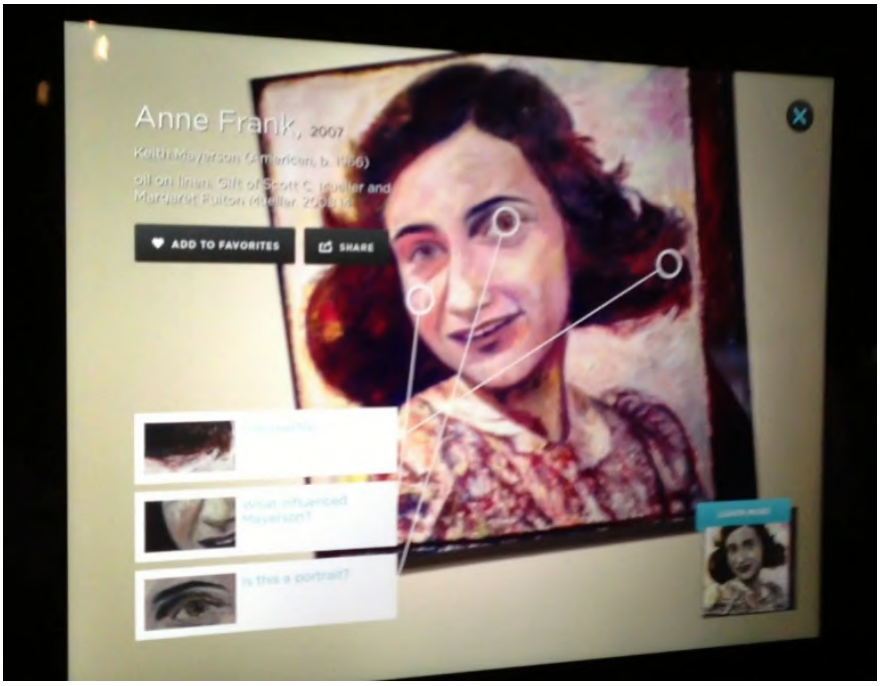

Figure 7: A scene of how the "Skin and Bones" app work
Source: `https://www.youtube.com/watch?v=q-rziZHc_7w`

can improve the interactivity and information presentation for exhibit and thus enhance visitor's engagement and satisfaction when visiting these institutions.

Our project's core objectives are as follows:

- Analysis of the current research and applications on XR technology used in GLAMs, focusing on how XR, especially AR, is used to enhance the visitor experience.
- Display information related to showcased items and present as immersive virtual content in forms of different multimedia, such as image, text, and video, to improve visitor's learning experience.
- Provide an interactive and user-centered AR interface that can enhance visitors' engage with exhibits, where visitors interact dynamically with the virtual content.
- Investigate the impact of AR technology on the overall visitor experience, especially on the visitor's engagement, interactivity, and information intake.

4 Methods

4.1 Unity Game Engine

The prototype will be developed on one of the main game engines, Unity, which supports developing and exporting XR applications to different platforms, including Windows, Android, and iOS. The primary programming language will be C#, as this is the development language used by the Unity engine.

4.2 AR Assets and Toolkits

Relevant assets and toolkits for AR development, such as Mixed Reality Toolkit (MRTK) [25] and ARFoundation [26], will also be used with Unity for the development. Specifically, MRTK will be used to implement the virtual element's interaction and interface. Meanwhile, ARFoundation will be used for tracking the exhibited object for positioning the virtual content element based on the object's location.

4.3 XR Head-Mounted Device

Currently, more AR applications are developed for XR head-mounted devices. This prototype will be developed for state-of-the-art optical see-through XR devices, such as Meta Quest Pro, because their wider field of view, higher contrast, and brighter display of virtual elements compared to video pass-through devices can provide a better immersion for the user [27, 28].

5 Deliverable

The successful completion of this project will result in two key deliverables: a functional AR prototype with an interactive interface for the exhibit's information display and the user study result that analyses the impact of AR technology on visitors' experience within the exhibit. Please refer to Session 3 for the detail expectations and objectives for the AR prototype and user study result.

6 Project Schedule and Milestones

Date	**Milestones or Deliverable**	**Details**
Sep 2023	Research	• Literature review on interactive exhibits and existing GLAM AR applications (Session 2) • Research on the tech stack (Session 4)
1 Oct 2023	Deliverables of Phase 1	• Detailed project plan • Initial project Web Page
Oct 2023	Pre-Development	• Study ARFoundation and MRTK on how to implement AR tracking and interaction with Unity • Get familiar with the head-mounted device used for development
Nov 2023	Exhibited Object Tracking	• Detect and track the exhibited object with ARFoundation
Dec 2023	User Interface (UI) for Information Display	• Create virtual elements that can be located based on the position of the exhibited object • Implement interactive UI with intractable virtual elements using MRTK
Early Jan 2024	Finish Prototype Version 1	
8-12 Jan 2024	First presentation	
21 Jan 2024	Deliverables of Phase 2	• Preliminary implementation • Detailed interim report
Late Jan – Feb 2024	Initiate User Study	• Design the elements, flow, and survey • Invite the participants
Mar 2023 Mid Apr 2024	Conduct User Study & Analyse the Result	
15-19 Apr 2024	Final presentation	
23 Apr 2024	Deliverables of Phase 3	• Finalized tested implementation • Final report
26 Apr 2024	Project exhibition	

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