Time Travel as a Visitor Experience: A Virtual Reality Exhibit Template for Historical Exploration

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Abstract. Developments in digital infrastructures and expanding digital literacies lower barriers for museums and visitor centres to provide new interactive experiences with their collections and heritage. With virtual reality more accessible, heritage institutions are eager to find out how this technology can create new methods in interpretation, learning and visualisation. This paper reviews virtual reality exhibits that were built and displayed in cultural heritage centres. By taking advantage of existing visitor digital literacies, the exhibits provided accessible immersive exploratory experiences for inter-generational audiences. The digital framework developed is a template for virtual reality content interaction that is both intuitive and powerful. The exhibits include digital reconstructions of a physical scenes using game engines for a convincing visual experience. We contextualise the logic behind a virtual reality setup for the separate institutions, how they assisted with the narrative as well as if an immersive digital environment provided a more profound response in users. Our aim is to communicate approaches, workflows and content used to overcome the challenge of presenting a period in history to a modern audience, while using emergent technology to build connections and disseminate knowledge that is memorable and profound.

Keywords: Virtual Reality, Cultural Heritage, Museum Exhibits.

1 Introduction

Opportunities presented by advancing technology can be used to enrich and connect the visitor to archaeological and historical research in ways which provide an authentic experience [1]. This paper suggests a framework for virtual reality (VR) exhibits located within cultural heritage visitor centres and museums. It draws upon experience developing and deploying VR interactives for museums.

The application of emergent technologies to cultural heritage offer the opportunity to: widen participation in its construction, deepen understanding through holistic interpretation, connect researchers and communities, communicate knowledge in engaging and accessible ways, and stimulate debate leading to further research.

The paper looks first at the context for the work, developing a conceptual framework and placing VR exhibits in the context of media such as movies and games. Next, we consider a practice-based methodology and workflows used for creating VR exhibits. This is followed by discussion and evaluation of two exhibits. We then discuss a

framework for creating exhibits, that is based upon this experience and discuss the final exhibit developed using the template.

2 Context

Museums, as defined by UNESCO, are the guardians of tangible and intangible heritage, as well as responsible for their "preservation and promotion" [2]. The ways in which museums and other heritage institutions have 'preserved and promoted' their own narratives have evolved from simple displays to investing in the visitor experience [3]. Museums have also established themselves as modern cultural and community hubs, not just forums for knowledge transfer, enabling community members to contribute, express views, and tackle issues that are pertinent to society [4]. This evolution allows for greater visitor participation and deepens ties between community and its heritage [5].

Popular media has had an interest in presenting the past for over a century; from silent films, cowboy novels now to period video games. Historical narratives drive multiple gaming franchises such as Assassins Creed, based in an open world environment, and simulation games such as Total War and Age of Empires. Successful commercial games use elements of learning theory, which attributes to user engagement [6]. Since history-based video game popularity has proven the medium is engaging and immersive, institutions such as museums have begun to follow suit by exploring possibilities with emergent technologies.

VR offers the possibility of combining the visual power of films with the interaction of games in an immersive setting that transports users to locations remote in time or space. This immersion can include full scale VR room set ups [8], interactive projections [7] and headsets which can lead to transformative experiences. The continuous research and development of VR along with increasing digital literacies implies that it is possible to deliver large scale VR scenes in museum exhibitions that are accessible and comprehensible to most visitors. This in turn allows for intensive dissemination that connects a user with the narrative of the exhibit, strengthening the relationship between themselves, heritage and the exhibit's message.

Previous projects that lay the foundations for the VR exhibits we examine are based in Scotland; the Virtual Museum of Caen, The Bannockburn Visitor Centre, the Picts & Pixels Exhibition at the Perth Museum and Art Gallery and the Curing Yard. Collaboration between ourselves and Timespan Museum and Art Gallery developed digital representation of Caen, a pre-clearances Highland village in the Strath of Kildonan [8]. This included a VR room where visitors controlled an avatar using an Xbox Kinect to explore a reconstruction of the village. The Bannockburn Visitor Centre allowed visitors to fight the Battle of Bannockburn themselves, changing the outcome based on the user's decisions. The Picts & Pixels exhibition adopted a mixed reality approach in which physical objects and digital exhibits were displayed in parallel and

complementary to one another [7]. Interactive photospheres, digitised models and a VR headset facilitated multimodal interaction with the world of the Scottish Picts. The Curing Yard was a second collaboration with Timespan Museum, which included an immersive controller-free VR headset exhibit of a curing yard, historically represented in the exact location of the install within the museum [9].

3 Methodology and Workflows

Our procedural methods for digital cultural and natural heritage projects are practice-based. This enables us to identify real world issues and creatively address them, while meeting the immediate challenges provided as well as contributing to more general solutions.

Implementation of the VR Exhibit Template (VRET) was made when the projects were in early stages of development. Each collaboration had a wealth of resources and materials that would supplement their chosen narrative and wished to experiment with latest technologies. Digital reconstructions were to be in each project as a base of work, along with a combination of provided and newly generated content.

Stakeholders worked in collaboration throughout the development of the exhibits; the majority experts in the related subjects, such as archaeologists, historians, archivists and museum professionals. Scenes to be digitally reconstructed were discussed with the OVW team and those affiliated; decision making and adjustments occurred throughout the entirety of the builds. Selection of objects to be digitised, sites for aerial and spherical footage and narratives were chosen early in the creation process. Content varied between exhibits, based on what was available to the team and the level of importance to the overall narrative.

By further developing of the technology and interpretation for use in museums, the framework has the possibility of connecting ourselves and our work with institutions as well as their network of organisations. This offers the opportunity for bilateral knowledge exchange. In each project we arranged workshops and discussions with local partners, to better understand the needs of the organisations and to deepen local understanding of both the historical research and technology which shapes the exhibit.

3.1 Workflow for Creating Virtual Reality Exhibits

The workflow for VR exhibit creation is a multistep process. The first phase is to identify the subject and possible narratives to be used to tell relevant stories. This is followed by identification of digital resources to be used in the project, pulling from an inventory of existing resources or media to be created. Digital resources often consist of terrain, models, photospheres, aerial footage, video, audio and historical photos. Finally, an investigation into best methods for navigation of media and narratives, which includes interpretation and interaction, is included into the system design.

Landscapes and Terrain

Terrain data acquired from appropriate sources, such as Ordinance Survey (OS) data or LIDAR data, are often dictated by region. Data is combined from the supplied tiles into a single GeoTiff file using QGIS* (open source geometric information system). An OpenStreetMap layer is required as well as a shapefile with polygons for the extent of the terrain. A print layout is necessary from the supplied data and layers to import the terrain into Unreal Engine 4 (UE4).

The information is imported into World Machine, a 3D terrain generator, to a file with existing set of nodes. The heights of the terrain are programmed into the project properties and extents for desired map locations are created. By selecting extent and output nodes, processing results in a PNG file that are used to create a terrain in UE4.

The terrain material is copied to a new project in UE4. A new level is required to host the terrain and relevant files. A spreadsheet is used to calculate the location and scale values for the terrain. The following calculations create a large terrain seen in Figure 1.

The x/y scale is determined in meters by the following equation:

$$\left(\frac{real\ size}{(PNG\ size - 1)}\right) \times 100 = x/y\ scale$$

Z scale is determined by the following equation:

$$\left(\frac{height\ range}{512}\right) \times 100 = z\ scale$$

The z location is determined by the following equation:

$$\left(\left(\frac{height\ range}{2}\right) + minimum\ height\right) \times 100 = z\ height$$

Fig. 1. Large scale terrain created for Tomintoul exhibit.

System Design and Implementation

The exhibit system is built in Unreal Engine 4 (UE4) and is demonstrated in the diagram Figure 2. The built UE4 executable runs using a system called Chimera. Chimera provides on-screen overlays and videos. UE4 and Chimera communicate over a network connection using a plugin to UE4 which was purpose created. This plugin allows the developer to send and receive messages in a text format between UE4 and Chimera.

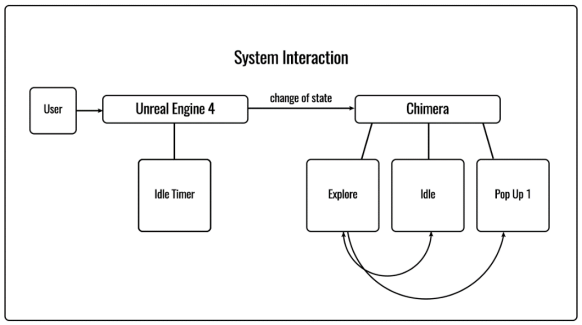

Fig. 2. System interaction with the user.

In the VR exhibits, the UE4 executable drives the interaction by taking input from the user and signaling to Chimera to change state in order to display information to observers. The UE4 game consists of a single persistent level and several streaming levels which are loaded when needed, seen in Figure 3. When the user starts interacting with the system, they see a menu system in the Start level which is loaded when the system starts or returns from the idle state. The menu provides 3 or 4 buttons to the user. To select these buttons the user looks at them and then presses the center navigational button.

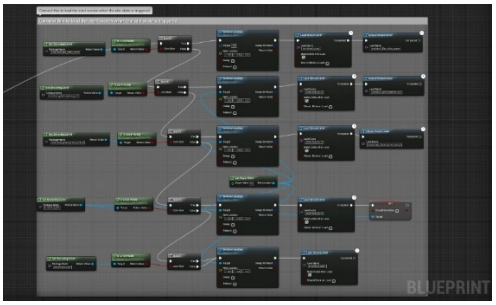

Fig. 3. Blueprint structure of persistent and streaming levels in UE4.

The system registers when the idle count reaches the specified value and transitions to the idle state by sending a message to the Chimera to display the idle video. Chimera does this by changing to an internal state where it displays a video, seen in Figure 4. When a user then interacts with the system by picking up the headset, UE4 signals Chimera to return to the main play state, which removes the video from the screen.

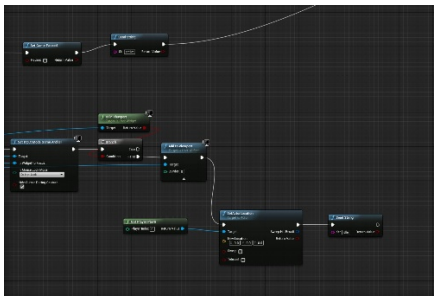

Fig. 4. Blueprint structure of idle state in UE4.

The exhibit has a purpose-built startup script which initiates the programme and also creates a connection to a server using an SSH server setup which is used to log in to the remote machine. A VNC server runs on the remote machine which allows remote access to the desktop without required a fixed IP address. All VR exhibit have the aforementioned capabilities, allowing for automatic start up and remote access for addressing system issues.

4 Exhibiting Illicit Still and Icelandic Monks

4.1 The Illicit Still Experience (Tomintoul & Glenlivet Discovery Centre)

The Tomintoul & Glenlivet Discovery Centre (TGDC) is in the highland village of Tomintoul surrounded by the Glenlivet estate. Whisky has played an important role in the area's history, taking advantage of the surrounding landscape and continues to be a crucial part of the local and Scottish economy. With the HLF and LEADER funded redevelopment of the Discovery Centre in 2017, the Tomintoul & Glenlivet Development Trust (TGDT) and Tomintoul & Glenlivet Landscape Partnership (TGLP) were interested in using HIE Year of History and Heritage funding to install an immersive interactive exhibit that could accomplish the following goals: 1) communicate the connection between the natural and cultural heritage of the area 2) compliment other whisky displays in local distilleries with historical beginnings of the industry 3) show the landscape and archaeological sites as historically accurate as possible in the 18th century 4) invest in emergent technology that would be best suited for visually telling their narrative, interest visitors who may not have used the technology before and facilitate new experiences in the future 5) generate enthusiasm for visitors to explore the sites themselves 6) allow accessibility to sites if visitors could not physically do visit.

Elements of the VRET for Tomintoul were based off design and functionality changes after the VR installation in the Picts & Pixels exhibition. This included a single button design as opposed to a controller-based design which simplified user interaction. The exhibit featured similar components such as a VR Oculus headset, a screen, spherical images and 3D reconstructed environments. The exhibit comprised of a digital reconstruction of Ballanloan, an 18th century settlement of cottages and kilns, an illicit

still hidden in a cave next to a stream and barley fields. Historical and landscape evidence were provided by Ordnance Survey (OS) data. Content included the digital reconstruction implemented as both a descriptive photosphere tour and as an environment for open world exploration as well as a real-world photosphere tour, shown in Figure 5. As a request, a virtual theatre option was developed to show videos of both the digital reconstruction and real-world aerial footage within the headset.

Fig. 5. Example of real content in photosphere tour, Glenlivet Distillery.

4.2 Skriðuklaustur Monastery (Skriðuklaustur Cultural Center & Historical Site)

Skriðuklaustur is in the east of Iceland where a Catholic monastery and a consecrated church were found to be inhabited during the 1500's. An archaeological excavation began in 2002 at the site and continued for a decade after. The excavation uncovered the building foundations, information about the building materials used and unique artefacts [10]. Ongoing projects have been exploring the site through technology; a previous reconstruction of the monastery, aerial footage shot along a proposed route to the monastery over a glacier, and digitisation of objects from the excavation. Continuation with the newest iteration of the reconstruction led both researchers and Skriðuklaustur to choose the VRET as an appropriate method of content interaction. The interactive's goals were: 1) to offer an updated visual representation of the monastastic ruins 2) create an immersive experience by allowing visitors to explore the ruins inside and out 3) allow accessibility for visitors who cannot visit the site or when weather restricts access 4) use emergent technology that grants full immersion into a period in Iceland's history 5) an attraction for visitors to visit the remote museum.

Skriðuklaustur was the next evolution in the VRET design and functionality after its installation in Tomintoul. The single button was kept for simplicity as the remote encouraged use. The exhibit features an Oculus headset, a screen, photospheres, digital reconstructions and 3D objects added into the reconstruction. The updated reconstruction of the monastery and the surrounding landscape was included, as well as the interiors of the church. 3D digitised objects were placed back into the reconstruction as they would have been found during that time. The digital landscape was built from terrain data provided by the National Land Survey of Iceland. Content levels included a descriptive photosphere tour, a 3D object gallery to interrogate artefacts and a video theatre for real world and virtual footage.

5 Evaluation and Evolution of Design

All exhibit that are used for cultural and natural heritage dissemination go through multiple assessments before, during and after installation. The systems are evaluated from the following perspectives: 1) community 2) museum 3) non-community visitors 4) field specialists, as well assessing the following aspects of the system: 1) usability 2) responsiveness 3) enjoyment 4) engagement 5) learning 6) motivation for further learning.

Laboratory research and evaluation has been ongoing since the creation of the VR exhibit framework; originally the Curing Yard, a single level exhibit for Timespan museum, and then a multi-level exhibit for the Picts & Pixels exhibit in Perth Museum & Art Gallery summer 2017. Evaluation from the first exhibits evolved design and system methods to implement changes for the next exhibit, the Illicit Still Experience for TGDC. Exhibits included in this publication have developed from installation, use and evaluation of the previous, leading to dynamic and effective framework.

Based on user evaluation at an open day event for the Picts & Pixels exhibition, users reported the Xbox controller was hard to use as the VR headset occluded the user field of vision [7]. If the user did not have video game experience nor read the instructions before wearing the headset, they had trouble associating directions navigators to the buttons associated on the controller. User evaluation from the Curing Yard showed the benefits from a hands-free system but lacked navigational ability for multiple levels [9]. Due to this response, the Oculus controller was adapted for future use as it was more functional and efficient than controller-free design yet less complex than a multi-button game controller. Skriðuklaustur retains the Xbox controller due to an initial supply issue but is due to switch over to the Oculus remote in the future.

An internal assessment of the look and feel and usability of user interfaces within the levels, along with informal user evaluation in the field, confirmed that the descriptive photosphere tour was not intuitive and had issues with textual display. After installation in Tomintoul, its design evolved for Skriðuklaustur but was completely redesigned for Finlaggan. It was decided to combine the photosphere tour with the open world exploration level, allowing for a narrative along with open environment exploration.

5.1 Organisational Evaluation - Tomintoul

Museum staff at TGDC have recorded informal evaluations since the installation of the exhibit in spring 2018. Evaluations in this publication include interaction and mode of engagement, while written assessment has been recorded in visitor log books. Future plans include VR and exhibit elements taught in workshops at TGDC and formal evaluations of visitors and attendees to be included by publication of this paper.

Interaction
TGDC caters to a wide variety of visitors while it is open to the public during the peak tourist months of April through October. The centre opens for events and groups during the winter months, allowing year-round engagement with the VR exhibit. By October 2018, 10,000 visitors had gone through the centre, a 20% increase from 2016 and 50% increase from 2014 [11]. The redevelopment of the centre and its use of VR received national recognition from First Minister Nicola Sturgeon when she toured in August 2018.

Dedicated staff do not supervise the exhibit but are stationed nearby at a front desk for any needed guidance and support. Thus far, there has been a wide age demographic of users with varying level of technical skill. As a result, staff have been able to observe diverse interactions and trends with the exhibit. Users tend to investigate the open world exploration level for the longest period of time, likely due to the explorative nature of the level itself; gameplay length is largely dictated by presumed comprehensive completion of the environment. Details in the open world environment such as the farm animals have been of interest to younger users.

A spinning office chair is in place for mandatory use for those using the VR exhibit to limit wandering and accidents, while encouraging freedom to explore the entire 360-degree space. This has sometimes become difficult with the hardwired Oculus Rift and gets caught if users spin in a complete circle. Staff have concluded that though entanglement occurs occasionally, the chair relieves users from too much disorientation, granting staff at the front of house the ability to concentrate elsewhere.

Modes of Engagement
In TGDC, the exhibit is installed in a corner of the main room, where visitors enter and move on to explore the traditional exhibition or the digital library area. As a room where visitors begin their tour, groups of people can accumulate, limiting the direct use of the VR headset. This demonstrates the use of the screen as an important type of engagement, as the exhibit can be a social activity for a large group as well as self-promoting itself for later use if there is a queue. This type of engagement has received positive response by visitors as an unexpected aspect to the exhibit.

5.2 Organisational Evaluation - Skriðuklaustur

Museum staff have recorded informal user evaluations since the exhibit's installation, including interactions at external events. The installation has been on display at the museum since August 2018. Evaluations have included ease of use, interaction, type of engagement from visitors, and reactions to supplementary content.

External events included Tæknidagur fjölskyldunnar (Technology Day for Family) with over 1,700 attendees and Að heiman og heim - náms og atvinnulífssýning Austurlands (education and work opportunity event in East Iceland) with over 200 people who

used the exhibit. Scholarly users at the museum have included archaeologists, authorities involved with archaeological sites and excavations, game developers and museum professionals.

Interaction

Museum staff are posted in the room hosting the VR exhibit in order to help guests and navigate them through the levels. Most guests have limited VR experience and often require guidance with the headset and Xbox controller. The Oculus Rift 'guardian' feature enables users to find the sensor tracking boundaries, but restricting movement further deters wandering and accidents. The addition of knowledgeable staff alongside the VR increases the depth of experience for a user. The visualisation of VR and the included media constructs a connection that encourages understanding of contextual data, such as from an archaeological excavation. Users reacted when told the height of a ceiling by leaning back and looking, just as most would in the reality.

When taken out to events, staff reported that a younger age demographic tend to approach and use the exhibit, as opposed to a wider age demographic found at the museum. User at the external events tend to have used VR or video games before, so functionality of the VR exhibit and operability of the navigation through the Xbox controller requires less explanation.

Users have found the headset occludes a user's view of the controller, navigation through a multi-button layout is challenging if there is no prior gaming knowledge [7]. The installation retained the current controller layout as an Oculus remote did not arrive on time for installation but will be switched over in the near future.

When visitors use the exhibit in VR mode with the headset, the experience has been reported to be different than those who watch on the screen. The functionalities of the exhibit are realised when using the VR headset and controller, and elements of those capabilities do not completely transmit to passive engagement. Users reported to enjoy "zooming in" on objects in VR while in the 3D gallery, utilising body movement to enhance their experience.

Modes of Engagement

The dual set up of the headset and screen have allowed for both active and passive engagement, but staff have encouraged visitors to engage with the headset even when first reluctant. The assumption that the passive engagement of watching the screen is identical or similar enough to the interaction with the headset. The distinction between the two types of engagement has been noted by visitors that try both to be significantly different in how they interact with the content.

Large tourist groups are frequent visitors to the museum and often stay in groups through the galleries and rooms. The passive engagement offered by the screen satisfies visitors when in a group situation, as one user engages with the headset, the remaining

watch their actions. Staff that assist with the VR exhibit explain what is shown on the screen to the group as well directing the user to different parts of the exhibit.

6 VR Exhibit Template (VRET)

6.1 User Interface and Design Priorities

Physical Design
To facilitate both an individual user and groups, the exhibit consisted of 1) Oculus VR headset 2) a sensor for tracking headset movement 3) navigational controller 4) large screen for mirroring actions within the headset. Each exhibit is in a central point in the museum or centre to maximise its discovery and use by visitors. This also allowed large groups to engage with the exhibit passively through the mirrored screen; turning the exhibit into a social activity, as well as provide direct intellectual stimulation to the active user.

Exhibit Design
VRET can incorporate several types of levels, all chosen from a menu system, showing in Figure 6. These include 1) an open world environment 2) photosphere tours, either real or virtual content 3) 3D model gallery for interrogating digitised objects 4) video theatre and 5) adapted open world tour.

Fig. 6. Menu system in VRET.

The goal for navigation was to make it intuitive and consistent across levels. Working within the Oculus ecosystem, a straight forward button system was applied. Controller-based interaction draws from digital literacies, specifically games proficiencies and familiarities. This is useful because a significant portion of the population play video games and these games offer benefits for learning and social interaction, hence by gamification of exhibits, museums can deliver interactive experiences to visitors using familiar technologies and devices [12]. Movement through an environment was achieved by pushing a button, then the viewpoint would move forward in the direction that the user was looking. Menu selection was achieved by the user looking at the level selection buttons, then clicking the main selection button when their desired button was highlighted. Progression through tours was through the navigation buttons designed on a

circle for non-visual prompting. When the exhibit is not in use, an idle video plays on a loop. When the user puts on the headset, the video is interrupted, and the menu appears for level selection.

Interaction is triggered through location and through focus on interaction points. The interpretation can be displayed in world or through a heads-up display. A user can click on a hotspot that will bring up a 3D artefact, created through photogrammetry or laser scanning techniques. This enables integration of digital and physical content within the exhibit.

A gallery-like 3D environment is used to house digital artefacts. The 3D gallery is designed to place less emphasis on the level of detail in the virtual environment, and more emphasis on the 3D objects. Interaction is built into the gallery so that users rotate artefacts around multiple axes, zoom in/out and move around the centrepiece. Users can switch between artefacts in a manner that is similar to navigating through images in a photo gallery. The framework also supports the simple virtual environment to switch to a real or virtual photosphere, giving the object its original context.

As part of further education and development, components of the framework have been made freely available in guides and downloadable templates for community members and heritage practitioners with basic UE4 experience [13]. Users can combine assets and functionality templates into game engine levels, populate levels with their content and package them to create immersive museum installations.

7 Lord of the Isles

Finlaggan was a seat of power for the Lord of the Isles and Clan Donald, who ruled over parts of mainland Scotland, the Hebrides, and Ulster. The site was used for council meetings, ceremonies and entertaining, and is located on the Scottish island of Islay, now famous for whisky distilleries. The visitor centre is located at the site and care for the ruins and has had a redevelopment. Archaeological excavations have occurred since 1990 which uncovered various buildings, tombstones and artefacts. Work is still ongoing, with further digitisation of objects for the exhibit's official opening in April 2019. Other sites around the island were documented through photospheres and aerial footage. The VRET was chosen as a platform for interaction due to the following reasons: 1) visually represent the numerous buildings, paths and boundaries from the site 2) allow visitors to explore inside many of the structures as well as the grounds around them, to further understand Medieval Scottish royal life 3) give the visitor centre a different platform to inform audiences of the narrative of the site 4) connect other sites on the island that are associated with Finlaggan to be viewed all from one location.

The edition of VRET that was used in Finlaggan has been the latest design to be installed and has gone through significant development. The exhibit includes a reconstruction of multiple buildings, key building interiors and the surrounding landscape. Based on evaluations from both Tomintoul and Skriðuklaustur, along with laboratory

research for more efficient exploration, the descriptive photosphere tour and open world environment were combined to create an open world tour. The physical exhibit included an Oculus headset, an Oculus remote, and a screen for passive and group engagement. Exhibit levels include the open world tour, a video theatre and a 3D object gallery. The landscape was built using OS data and corroborated with modern drone footage.

The adapted open world tour created specifically for the Finlaggan exhibit offers two avenues of investigation. The initial drop point in the tour displays text to give context to the scene and times out or disappears after a click on the controller. This specifically engineered system consists of descriptions of the parts of the reconstruction which are displayed to the user on the headset overlay and to the observers using the Chimera overlay for that location. This involves a state created for each location. The setup allows information to be formatted differently for the user and to observers. The user can navigate through the environment by pressing the main controller button and looking in the direction they want to move in or by pressing the left and right buttons which will take them to next information point, which displays more information about that point.

8 Conclusion

In conclusion we have presented experiences in developing VR exhibits for small to medium sized visitor centres and museums. From these experiences we have developed both a software template for VR exhibits that can be widely used in museums and visitor centres globally. We have also developed workflows for the creation of content for VR experiences.

We have found that the aforementioned is of value for the following reasons: 1) it makes heritage available to audiences in new engaging ways, 2) it acts a stimulus for an holistic approach to historic research and as a platform for stimulating controversy and discussion, 3) it engages local communities in the understanding and construction of heritage, 4) through enhancing the visitor experience the potential exists to stimulate the local and national economies.

Furthermore, we have identified issues of specific relevance to museums using VR technology, specifically: 1) the need to address ease of use; users will not expect to invest time required in learning to play a computer game. This has guided our approach to interaction and movement, 2) the requirement to make the system robust to minimise the need for input from museum staff and to maximise uptime, 3) flexibility to integrate different types of content together with the ability to connect digital artefacts with digital scenes, 4) to facilitate users in discovering points of interest, through direction, whilst providing the freedom to explore the environment and its content.

We perceive the VRET as one approach to applying digital and VR within the context of a museum. It collects together multiple forms of digital content and creates a

connection to current archaeological and historical research while ensuring a worth-while visitor experience.

References

1. Kalay, Y., Kyan, T., Affleck, J.: New heritage: New media and cultural heritage. 1st edn. Routledge (2007).
2. "Recommendation Concerning the Protection and Promotion of Museums and Collections, their Diversity and Their Role in Society", 2015., http://unesdoc.unesco.org/images/0024/002463/246331m.pdf, last accessed 2018/11/22.
3. A. Vermeeren, L. Calvi and A. Sabiescu.: Museum Experience Design: crowds, ecosystems and novel technologies. Heidelberg: Springer International Publishing (Springer Series on Cultural Computing)., 2018.
4. Cassidy, C. A., Fabola, A. E., Miller, A., Weil, K., Urbina, S., Antas, M., Cummins, A.: Digital Pathways in Community Museums. Museum International 70(1-2), 126-139 (2018).
5. Simone, N.: The Participatory Museum. Museum 2.0, Santa Cruz, California (2010).
6. McCall, J.: Gaming the Past: Using Video Games to Teach Secondary History. Taylor and Francis, Florence (2013).
7. Cassidy, C. A., Fabola, A. E., Rhodes, E., Miller, A.: The Making and Evaluation of Picts and Pixels: mixed exhibiting in the real and the unreal. Communication in Computer and Information Science. In: Beck, D., Allison, C., Morgado, L., Pirker, J., Peña-Rios, A., Ogle, T., Richter, J., Gütl, C. (eds.) 4th International Conference, iLRN, vol 840, pp. 97-112. Springer (2018).
8. Miller, A., Vermehren, A., Fabola, A. E.: The Virtual Museums of Caen: a case study on modes of representation of digital historical content. In: Guidi, G., Scopigno, R., Torries, J.C., Graf, H. (eds.) Proceedings of the Digital Heritage International Congress: Analysis & Interpretation Theory, Preservation & Standards, Digital Heritage Projects & Applications. IEEE, Vol. 2, pp. 541-548 (2015).
9. Fabola, A. E., Kennedy, S. E., Miller, A. H. D., Oliver, I. A., McCaffery, J. P., Cassidy, C. A., Clemens, J., Vermehren, A.: A Virtual Museum Installation for Virtual Time Travel-Communications in Computer and Information Science. In: Beck, D., Allison, C., Morgado, L., Pirker, J., Khosmood, F., Richter, J., Gütl, C. (eds.) 3rd International Conference, iLRN, vol. 725, pp. 255-270. Springer (2017).
10. "East Iceland Archaeological Site Unveils 3D Tour", Guide to Iceland Now, 2018, https://now.guidetoiceland.is/2018/09/21/news/east-iceland-archaeological-site-unveils-3d-tour/., last accessed 2019/2/27.
11. “NEW DISCOVERY CENTRE PROVES A HIT WITH VISITORS - Tomintoul & Glenlivet", Tomintoul & Glenlivet, 2018, http://tgdt.org.uk/new-discovery-centre-proves-a-hit-with-visitors/?fbclid=IwAR2p7EOVjTam-fX2Wwnlm_39srbJ8lOBR-dOS7eekdflHGS-BmXR7svh6WqA, last accessed 2019/2/23.
12. K. Lofgren, "2017 Video Game Trends and Statistics - Who's Playing What and Why? | Big Fish Blog", Big Fish Games, 2017, https://www.bigfishgames.com/blog/2017-video-game-trends-and-statistics-whos-playing-what-and-why/, last accessed 2019/2/23.
13. "VR Exhibit – Toolkits", Cineg.org, 2018, https://cineg.org/wordpress/toolkits/3d-exhibits/, last accessed 2019/2/27.