World Academy of Science, Engineering and Technology
International Journal of Humanities and Social Sciences
Vol:17, No:4, 2023

A Design of an Augmented Reality Based Virtual Heritage Application

Stephen Barnes, Ian Mills, Frances Cleary

Abstract—Augmented and Virtual Reality based applications offer many benefits for the heritage and tourism sector. This technology provides a platform to showcase the regions of interest to people without the need for them to be physically present, which has had a positive impact on enticing tourists to visit those locations. However, the technology also provides the opportunity to present historical artefacts in a form that accurately represents their original, intended appearance. Three sites of interest were identified in the Lingaun Valley in South East Ireland wherein virtual representations of site specific artefacts of interest were created via a multidisciplinary team encompassing archaeology, art history, 3D modelling, design and software development. The collated information has been presented to users via an Augmented Reality mobile based application that provides information in an engaging manner that encourages an interest in history as well as visits to the sites in the Lingaun Valley.

Keywords—Augmented Reality, Virtual Heritage, 3D modelling, archaeology, virtual representation.

I. Introduction

VIRTUAL Heritage pertains to the use of Information and Communication Technology (ICT) in cultural heritage applications such as virtual archaeology; which aims to restore ancient cultural artefacts as virtual representations of their original appearance. In this manner Virtual Heritage can be seen as a means to enhance people's understanding of history by enabling them to immerse themselves in environments that are true to the experience of their ancestors. The concept of Virtual Heritage applications can be traced back to the British Museum's 1994 conference 'Imaging the Past: Electronic Imaging and Computer Graphics in Museums and Archaeology.' This conference showcased virtual tours of Dudley Castle which comprised 3D computer visualizations of historical artefacts as well as on-site digital imaging systems for site documentation. This type of application – 3D computer visualization of ancient artefacts in either real world or virtual environments – remains the most common form of virtual heritage. Despite this concept being explored over twenty-five years ago, a number of obstacles diminished the momentum of projects in this area, such as: development complexity, inaccessibility of technology and complexity in usability [1]. However, advances in mobile device technology (smart phones and tablet devices) accompanied by their reduced cost and resultant uptake by mainstream consumers have led to a greater awareness and accessibility of Augmented Reality (AR) and Virtual Reality (VR) as users could feasibly utilize their own smart phone and tablet devices to interact with virtual artefacts in an AR or – via standalone affordable wireless VR Head Mounted Displays such as Oculus Quest 2 – VR based experience.

Stephen Barnes is with Waterford Institute of Technology, Ireland (e-mail: stephen.barnes@waltoninstitute.ie).

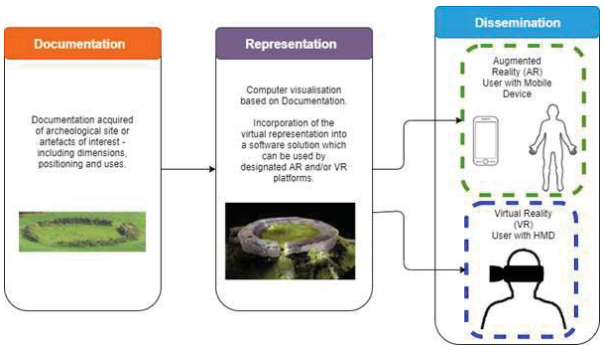


Fig. 1 The Virtual Heritage approach that was used

II. Approach to Virtual Heritage

The design principles which should be considered in creating an optimal virtual heritage solution include: low cost, photorealism, flexibility, portability and model size efficiency [2]. One of the principle elements of Virtual Heritage being to offer users an authentic experience of the environments and/or artefacts as they would have appeared in their original time. The means by which this can be achieved comprises three main components: Documentation, Representation and Dissemination.

The Documentation phase would encompass a capture of the dimensions of specific artefacts as well as physical attributes of places, objects and people. This phase would also comprise 3D mapping and image capture of either environment, specific artefacts or both. The Representation phase would take the documented information (including 3D models of the artefacts or environment) and create a 3D visualization of how they would have appeared at the time of interest. For example, the 3D model would take the form of the artefact as it would have appeared one thousand years ago. Representation would involve importing these models into a software platform such as Unity and Unreal Engine to add interactivity and other data, all of which would enhance the experience of users interacting with the virtual artefact. The Dissemination phase would incorporate the development of a software application encapsulating the experience and its deployment to either an

AR or VR based device platform. The decision for target platform and whether the extended reality (XR) experience is designated for AR or VR devices would be made prior to design of the application. This would include consideration of the different levels of required functionality, all of which is dependent on device limitations, as well as the requirements of the intended experience showcasing features of the heritage items of interest.

III. Background and Goal of Project

The project in question pertained to the virtual reconstruction of artefacts at several locations along the historical Lingaun Valley located in the South East of Ireland. Among the artefacts to be found along the valley are Western Ossory high crosses which are considered to be among the earliest high crosses [3] and may have had a function as elaborate – if somewhat unusual – territorial markers. The high crosses may have been associated with King Cearball Mac Dúnlainge (c.860-900), or possibly Maelsechnaill Mac Maelrunaiidh (859-62) [4]. These locations included:

A. Kilkieran

An area that had been the location of a monastic and perhaps a pre-monastic settlement in the Lingaun Valley [10]. The region and artefacts of interest for the Virtual Heritage project are the graveyard and the remains of its four high crosses. Two of which are substantial early crosses with rectangular bases and conical capstones. A third cross is more slender, taller, on a circular base. All that remains of the fourth cross are part of the shaft [5]. For the purpose of the virtual restoration – and as noted in the Documentation section – the remains of this cross were located on display at Jerpoint Abbey.

B. Killamery

The Killamery site is close to the foot of a hillside, at a springline and on a major overland route. It comprises a high cross, a graveyard, a holy well, the stump of a medieval church as well as the derelict shell of a post medieval church. The locality also has historical significance due to the creation of the Killamery Brooch by craftsmen in the Viking Age. It is a fine piece of metalwork first discovered in the 19th century [6].

C. Knockroe

The passage graves at Knockroe were built about five thousand years ago as a pair of artificial caves for storing the dead [7]. This passage tomb is a megalithic monument with most of the uprights (orthostats) around the chambers and along the short passages remaining in place on site along with most of the capstones. Although Knockroe passage tomb is part of a wide ring of similar caves built around Slievenamon hill, it is unusual due to the presence of a good deal of decorated stonework. A number of the stones used in the construction have been removed at some stage in the past five thousand years and it is surmised that the local field boundaries – build in the 18th or early 19th century – may have absorbed a great deal of the smaller stones such as kerb stones [11]. The Knockroe megalithic monument is famed for its artwork with inscription on stones in the two passages as well as on a number of the kerbstones. It represents the largest collection of megalithic rock art on a monument outside the Boyne Valley in Ireland. However, the meaning of the symbols remains a mystery. Passage Tombs are believed to be communal graves, resting places for cremated and non cremated remains. Knockroe is no different with over fifteen kilograms of cremated bone being recovered from the eastern passage [8] along with large quantities of cremated bone, unburned bones as well as a selection of pendants, pins and a vase food vessel being discovered at the western passage [9].

Fig. 2 Investigation into the assemblage of the Knockroe Passage Tomb by Archaeografix

IV. Documentation

The process undertaken for this project comprised working with an archaeologist, Dave Pollock of Archaeografix, to investigate and detail the ruins of the three aforementioned sites as well as to inform a reconstruction of the artefacts including identification of materials – such as quartz and Devonian red sandstone – that had been used in the artefact construction. The archaeologist also researched the artwork for the faces of each of the high crosses as well as the assembled appearance of the passage tomb at Knockroe.

The focus of the reconstruction also encompassed the appearance of each of the sites, which would lend itself to a greater sense of user immersion by viewing how each of the artefacts of interest would have appeared at the time of their construction. The archaeologist provided information and sketches for the environments,

This information provided a guide to how the stones - which are still present at the Knockroe Passage Tomb site - could have been aligned at the time of its construction. These stones were photographed and captured for modelling. An alphabetic key was used, assigning letters to each stone as reference for the representation of each stone in artwork and 3D modelling of the tomb reconstruction.

The information from the archaeologist was then passed to an Art Historian, Bettina Norton, who was able to provide detailed images for how the sites would have appeared at the time the artefacts of interest were created.

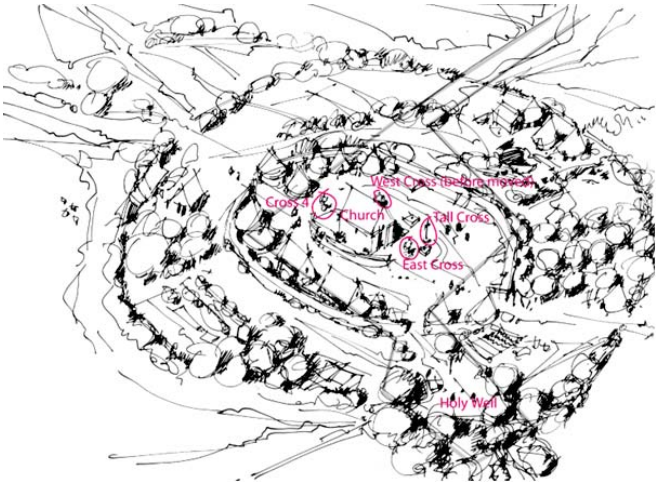


Fig. 3 Oblique sketch of the Kilkieran site as it would have appeared in the 9th century

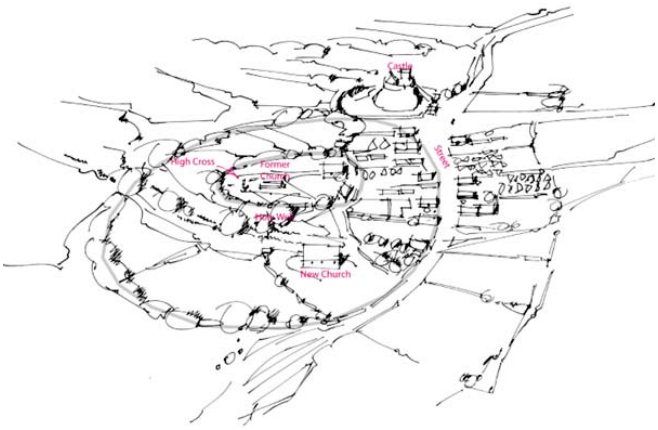


Fig. 4 Oblique sketch of the Killamery site as it would have appeared in the 13th century

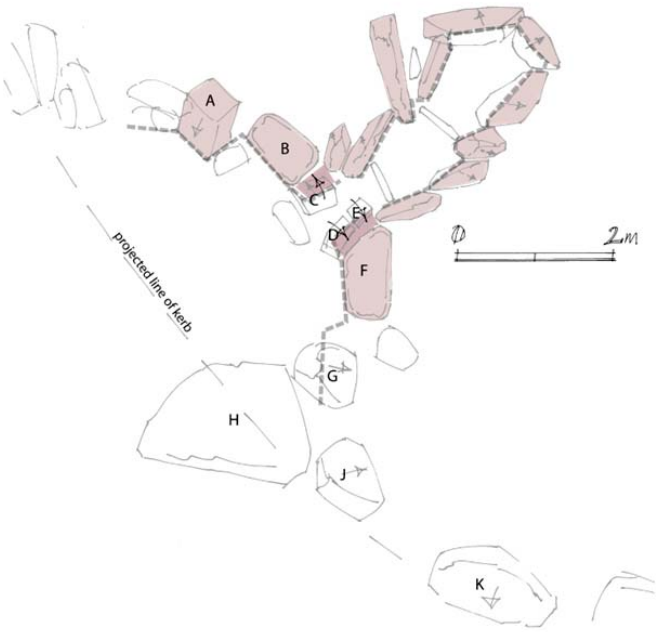


Fig. 5 Layout of the referenced standing stones at Knockroe indicating their original positioning

Fig. 6 Depiction of the Knockroe Passage Tomb and its environs

TABLE I
KILKIERAN WEST CROSS

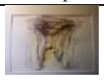
Artist Depiction	Final 3D Model
	

V. REPRESENTATION

The Art Historian based their work on a combination of photographs taken of each artefact during site visits – to determine artefact geometry – as well as insight provided by the archaeologist and published sketches [12] to represent how each artefact would have looked when it was first constructed, prior to the centuries of erosion and man made alterations to the artefacts. There were limitations to this technique due to the missing sections of a number of these artefacts – such as the head of the East Cross at Kilkieran and a number of the stones that constituted Knockroe passage tomb no longer being in situ. In these cases there was a reliance primarily on historically accurate data acquired by the archaeologist and illustrations [12]. The Art Historian provided profile sketches of each of the artefacts, which was used – along with photogrammetry techniques to indicate incisions and geometric shapes in the weathered stone of each – as a basis for 3D visualization of each artefact. The 3D modelling software – Autodesk 3DS Max and Autodesk Maya – was then used to create 3D models for each artefact.

In addition to the 3D model representation, the findings

TABLE II
KNOCKROE PASSAGE TOMB

Artist Depiction	Final 3D Model
	

of the archaeologist and art historian were also used in a 'Histories' section for the mobile application to enrich the AR experience for users with assorted image and text information provided for each of the artefacts and the heritage sites of the area. This included information around specific segments of the reconstructed artefacts such as the art adorning faces of the crosses or the standing stones of the passage tomb.

VI. Dissemination

The requirements for this application outlined that it should encourage users to visit the local sites of interest. Also, the Lingaun Valley experience should be available to as many people as possible without the prerequisite of purchasing specific hardware to access it. Thus from a dissemination standpoint, it was decided that a mobile based AR application should be developed. In order to reach the widest possible audience, the application should be platform agnostic, thereby enabling users of Android and iOS mobile devices to be able to experience it. The application was developed using the Unity engine, not only for its flexibility in application development but also as it supports the ARFoundation framework. The ARFoundation framework combines the ARCore framework from Android and ARKit from Apple, the two current market leaders in performance both for the time being as well as in the near future thereby ensuring that the application may exist on a widely used platform in years to come. ARFoundation builds a unified abstraction layer on top of both platforms – Android and iOS – allowing the framework to see the device being used and selecting the correct software for it thereby being platform agnostic.

ARFoundation effectively wraps ARKit and ARCore low-level APIs into a cohesive framework which includes additional utilities, such as AR session lifecycle management and MonoBehaviours to represent detected features in the environment. Some of the supported features of ARFoundation – that were essential for the design and development of the Lingaun Valley AR application – include plane detection (horizontal and vertical), feature point detection, light estimation, feature point and plane raycasting and the Camera Image API. These features enabled the possibility for the application to instantiate 3D models of artefacts onto the ground adjacent to the actual artefact's physical position. Also, use of the light estimation API supported the homogeneous integration of the virtual into the real world environment with lighting information from the environment affecting the rendering of the virtual objects.

In addition to the artefact and histories documentation being included in the AR application; other features were added including 'hotspots' which, when activated, would enable the user to view artwork correlating to specific areas of the virtual artefact as well as enabling users to have the ability to capture photograph images of the virtual artefact in their real surroundings. The design and development of the application was also influenced by the COVID-19 pandemic whereby it was considered that users would not necessarily be able to visit the sites and view the virtual objects in their intended location but that a remote experience should also be considered. As

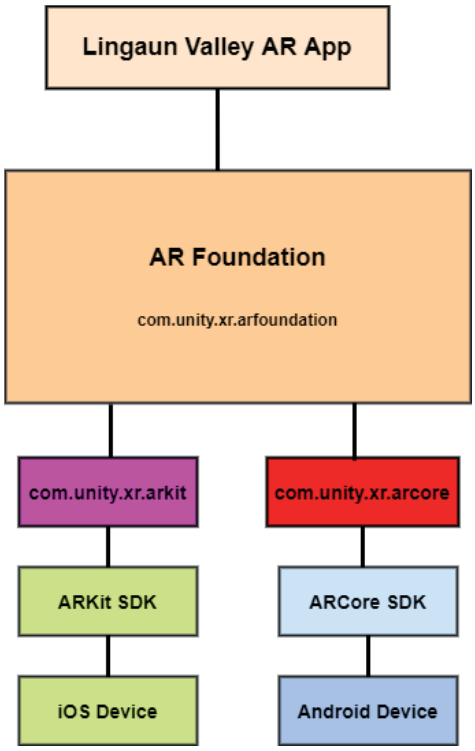


Fig. 7 Use of AR Foundation framework in developing mobile applications for Android and iOS

Fig. 8 A screenshot of the West Chamber Interior of Knockroe Passage Tomb

Fig. 9 A screenshot from the Lingaun Valley AR app of the Killamery High Cross

such, home based experiences were integrated which enabled users to view content from the comfort of their own home – either indoors or outdoors, with the initial scale of the object when it is instantiated as well as the lighting consideration for artificial or natural light considered accordingly.

Another key aspect of the design for the AR application was to be able to acquire metrics regarding use of the application: how many users download and/or run the application, specific times that are more popular both during the day as well as popular times during the year as well as identifying which of the artefacts is the most popular. As such an Administration Dashboard was created using Google Firebase with Google Analytics to determine the aforementioned and additional metrics. The Firebase Unity SDK enabled a smooth integration between the app and Administration Dashboard. The Lingaun Valley AR application was successfully launched on the App Store and Google Play Store in 2021.

VII. Conclusion

This project provided an Augmented Reality mobile based application, compatible with iOS and Android devices (that are AR Core compliant), to encourage both an interest in the heritage of the Lingaun Valley as well as enticing tourists to visit this region. The virtual models provided for each of the site specific artefacts of interest were created with a high level of historical veracity; owing to the comprehensive research and investigations undertaken by both the archaeologist and art historian. These models were created with a high level of physical accuracy utilising photogrammetry techniques explored at the 3D modelling stage. The owners of the Lingaun Valley AR application were also provided with a dashboard by which facilitates the addition of other sites in the locality, as well as the text, image, video and 3D model data specific to the site. Although, there has not been a detailed exploration into the use of the application and its alignment with increased interest - both remote and in terms of tourism footfall - in the sites of interest. The aforementioned dashboard provides the owners with analytics by which they can ascertain these metrics.

Acknowledgment

The authors would like to thank Dave Pollock of Archaeografix, Bettina Norton, Kilkenny LEADER Partnership and the Lingaun Valley Tourism Group.

References

[1] B. Tan and H. Rahaman. (2009). Virtual heritage: Reality and criticism. 143-156.
[2] H. Kolivand, A. El Rhalibi, S. Abdulazeez, P. Praiwattana and M. Tajdini. (2018). Cultural Heritage in Marker-Less Augmented Reality: A Survey. 10.5772/intechopen.80975.
[3] E. Rynne. (1998). “Ireland’s earliest ‘Celtic’ high crosses: the Ossory and related crosses” in M. Monk and J. Sheehan. *Early medieval Munster*, 125-37.
[4] R. Moss. *Art and architecture of Ireland*, Volume 1. Dublin: Medieval, 2014.
[5] M. Quinlan. (2011). Conservation Plan for the Western Ossory Crosses. Office of Public Works
[6] N. Whitfield and E. Okasha. (1992). The Killamery Brooch: Its Stamped Ornament and Inscription, The Journal of Irish Archaeology Vol. 6, 55-60
[7] M. O’Sullivan. (1993). Recent investigations at Knockroe passage tomb. JRSAI, 123, 5-18.
[8] M. O’Sullivan M. (1994). 1994:140 - ’The Caiseal’, Knockroe, Kilkenny, https://excavations.ie/report/1994/Kilkenny/0001749/
[9] M. O’Sullivan. (1995). 1995:172 - ’The Caiseal’, Knockroe, Kilkenny, https://excavations.ie/report/1995/Kilkenny/0002014/
[10] M. O’Sullivan and L. Downey. (2006). Holy wells, Archaeology Ireland vol 29 No.1, 35-7.
[11] M. O’Sullivan. *Heritage Guide No. 53: Knockroe-the prehistory of a valley near Slievenamon*, Ireland: Wordwell Ltd, 2011.
[12] P. Harbison.*The High Crosses of Ireland: An Iconographical and Photographical Survey*, Dublin: Royal Irish Academy, 1992.