Institution: University of St Andrews

Unit of Assessment: 11 – Computer Science and Informatics

Title of case study: Extending Open Virtual Worlds for Cultural Heritage and Education

1. Summary of the impact

Virtual Worlds are challenging to develop and deploy in small community settings. Our research into their measurement, design, and usability has allowed us to radically reduce the cost and footprint of a platform needed to support the collaborative creation of content, letting communities share their histories with both local and global audiences. Integrating this platform with an approach to virtual fieldwork lets communities explore authentic recreations of historical scenes, giving new perspectives on cultural heritage that stimulate reflection and understanding across the generations and enhancing the visitor experience by making new modes of interaction available for museums. This has enabled educational and cultural heritage bodies in Scotland to connect with new audiences and increase public participation in local heritage.

2. Underpinning research

The goal of our research was to adapt and develop emerging 3D technologies to create digital interpretations of the past connected to local communities. We aimed to meet the challenge of creating authentic historical scenes based upon expert evidence and interpretation, and to develop appropriate delivery systems to deploy these in museums and schools. This draws upon the experience of Miller, Dow, and Allison (Computer Science) in both systems research and technology-enhanced learning, and on the domain expertise of Sweetman (Classics), Fawcett (Art History) and Dawson (Archaeology). The research was structured along four strands: the use of 3D technologies in education (Sweetman and Miller 2008—10); Open Virtual World (OVW) system measurement and design (Miller and Allison 09—12); methods for creating authentic historic scenes (Miller, Fawcett, Dow, Sweetman 09—13); and platforms for delivering content over the Internet, in schools, in museums, and on-site (Miller, Dow, Allison 11—13). The research was funded by the EPSRC, HEA, and the University to a total value of over £300K.

Initial research developed support for virtual archaeological fieldwork. Prototypes using 3D game engines, VR and Second Life (SL) were developed and evaluated. SL was chosen due to its support for user presence through avatars and collaborative live development. The resulting application applied gaming methodologies within an integrated 2D web/3D OVW framework. Evaluation of system performance, reconstruction methodology, usability and educational value yielded the key insight that the resource's strong educational value was severely restricted by limitations resulting from the SL service model [4]. We therefore refined our OVW approach, removing all reliance on SL. Using open-source tools such as OpenSim required significant systems analysis and development, including measurement studies which identified distinct intra-application traffic classes with separate requirements and priorities [1]; system development to combine client-side window management with server-side rate control of network traffic [2] to improve control and reduce delay whilst being "fair" to external traffic; empirical studies of the relationship between Quality of Experience and Quality of Service identifying critical performance thresholds to drive optimisation; and measurement of client, network and server limitations to develop "balanced" systems [3]. The results of these studies facilitate the development, configuration, and deployment of OVWs that deliver an appropriate quality of experience.

Alongside these delivery innovations, the research pioneered a methodology which integrates software development, scholarship, real-world data, 3D modelling, and interpretation, to create historically-authentic 3D artefacts. This goes beyond digital reconstruction to recreation, modelling both tangible and intangible culture. Using this methodology, major artefacts including St Andrews Cathedral and Linlithgow Palace have been reconstructed and deployed to the public in interactive installations that are richly interactive and integrate with web resources to provide varied investigative pathways. Use in school classrooms and exhibitions demonstrate accessibility, engagement and positive learning outcomes [4,5].

Transforming a "hobbyist" virtual world into a general platform that supports multiple deployment

scenarios identified new challenges including walk-up-and use-interfaces, integration with existing applications, meeting curatorial priorities, and creating immersive displays within restrictive cost and environment constraints. In collaboration with Timespan, the OVW TARDIS project developed affordable immersive display ("CAVE") technology where an avatar is controlled by natural movement detected using a Kinect, and synchronised projections that can be arbitrarily placed to create an immersive environment [6].

The packaging of all this research into a **Virtual Time Travel Platform (VTTP)** supports collaborative creation of historic scenes and their deployment in heterogeneous environments, underpinned by a methodology for co-creation based upon archaeological, historical and digital data. Our research enabled Sweetman's and Fawcett's research into the likely form and use of the buildings, *"providing eminently practical ways of testing theories and assumptions. It is then of the greatest value for conveying more widely the understanding that has been gained"* [5]**.**

3. References to the research

[1] *Virtual worlds, real traffic: interaction and adaptation.* Oliver, I., Miller, A. & Allison C. Proc. 1st annual ACM SIGMM conference on Multimedia Systems. 2010. DOI: 10.1145/1730836.1730873. *A definitive account of Virtual World network traffic requirements and behaviour.*

[2] *Mongoose: throughput redistributing virtual world.* Oliver, I., Miller, A. & Allison, C. Proc. 21st IEEE International Conference on Computer Communication Networks (ICCCN). 2012. DOI 10.1109/ICCCN.2012.6289297. *Implementation and evaluation of QoS aware traffic management for virtual worlds.*

[3] *Towards the 3D Web with Opensimulator.* Oliver, I., Miller, A., Allison, C., Dow, L., Campbell, A., Davies, C. and McCaffery, J. Proc. 27th IEEE International Conference on Advanced Information Networking and Applications. 2013. DOI: 10.1109/AINA.2013.126. *This paper provides a measurement study that addresses the relationship between QoS and QoE.*

[4] *Games Methodologies and Immersive Environments for Virtual Fieldwork.* Getchell, K. Miller, A. Nicoll, J., Sweetman, R. and Allison, C. IEEE Transactions on Learning Technologies **3**(4), p. 281-293. 2010. DOI: 10.1109/TLT.2010.25. *A ground-breaking study that pioneers the use of virtual worlds to support virtual fieldwork.*

[5] *Exploring Canons & Cathedrals with Open Virtual Worlds.* Kennedy, S., Fawcett, R., Miller, A., Dow, L., Sweetman, R., Field, A., Campbell, A., Oliver, I., McCaffery, J. and Allison, C. Proc. UNESCO Digital Heritage Congress. 2013.

[6] *Exploring Heritage Through Time and Space: Supporting community reflection on the highland clearances.* McCaffery, J., Miller, A., Kennedy, S., Vermehren, A., Lefley, C. and Strikland, K. Proc. UNESCO Digital Heritage Congress. 2013.

4. Details of the impact:

Cultural heritage has recently embraced 3D technologies to impressive effect. The PiXaR film *Brave*, set in an imaginary Scottish castle, introduced millions to Scottish landscapes. The *Scottish Ten* project captured stunning 3D representations of heritage sites. Computer games like *Assassins Creed* enable exploration of historic scenes.

The VTTP platform complements these technologies and migrates them to community and research settings that are radically smaller than was possible before. Where *Scottish Ten* digitally preserves sites as they are today; VTTP enables authentic recreations of their heyday; where *Brave* present a single pathway through a fictional narrative, VTTP enables visitors to explore authentic scenes; where *Assassins Creed* delivers pre-defined scenarios to a global audience; VTTP enables community participation in the creation and exploration of scenes directly connected to communities.

Science awareness. The 3 month "Create and Inspire" public engagement course at Dundee Science Centre (12/2011—3/12) [S10] used VTTP and the St Andrews Cathedral reconstruction to create a multi-user exhibit which managed to *"take a vision, achieved through decades of scholarship of how this building was – and make it accessible to all"* [S6]. There were over 1000 visitors at "Science in the City" (3/12), including classes from 7 primary schools, STEM ambassadors, and all ages of the public. Visitor-book comments were unanimously positive: many suggested that the experience had contributed to revising their perception of the sites, and many

expressed a desire to follow up the experience by visiting the sites or by connecting to the reconstructions from home.

> "*Kids were very interested and enjoyed being able to interact with the Cathedral, the controllers are a medium that made it easy for them to do this (*77th Kelty Cubs). *This gives a new view to something which has interested me for many years. It helps put what you see on the ground into perspective* (Teacher). *Love that you are bringing history to life in a way children want to interact with* (Visitor). *I think it is great fun* (School Student)." [S9]

Others invited use in schools and museums, which we have since taken up. The VTTP has exhibited at over 20 venues globally including, by invitation Digidoc 12 *"the world's leading digital documentation and visualisation conference focused on cultural heritage"* (Cabinet Secretary for Culture and External Affairs) [S11].

Installations in Museums. On the 200th anniversary of the Sutherland clearances, using the VTTP and methods developed by Sweetman *" has produced the first virtual world with historical content, accessible in a cultural context in the UK; it has enhanced the visitor experience in our museum, and has put Timespan on the map as a forward thinking organisation with a growing national reputation"* [S7], The Timespan VTTP installation features a pre-clearance Caen Highland Township, *"a Scots township at the centre of an uprising in the19th Century … It offers a unique opportunity …. where gaming technology is married with historical information"* [S6]. The installation, with a 300" wrap-around display and natural body movement control, extends Timespan's story-telling room's functionality so that *"the visitor is able to not just sit and listen to a story but to be part of the story"* [S6]. The strength of the impact flows from an intuitive user interface, local content, local participation in content creation, and visually powerful 3D graphics. "*One of my own ancestors was cleared from Caen. … I can now sit in Timespan (or at home) and take my avatar through the township into the longhouses, corn-drying kiln and byres to see what my own ancestors saw. This is a surreal experience let me tell you!"* [S3]. At the public event to launch the Caen reconstruction, 100% of those who filled in questionnaires agreed or strongly agreed with the statements: *"The exhibit helped me imagine what it would have been like to live in Caen"* and *"I would now like to find out more about life in the Highlands"* [S13]**.** In the month following the launch (6/2013) there was a 32% increase in visitor numbers [S3]. Synergy with an excavation of Caen and photographic interpretation mean that "*all three elements … combine to make a powerful narrative … for those who like history and for those who think they don't"* [S6].

The low equipment cost (<£3000) and support for content creation make CAVE installations available to small museums for the first time. Embedding the VTTP makes its content available to Timespan's 13,000 annual visitors and web users, and connects with the 40 community groups that use Timespan's facilities including a group researching genealogy, the knitting circle, carol singers, local archaeologists, a meeting of local councillors, as well as primary, secondary and DAS school visits [S7]. The invitation to exhibit alongside Canadian Caen descendants at the Helmsdale Highland Games symbolises digital Caen Township's place at the centre of the local community. Following on from the Caen project, Historic Scotland, Creative Scotland and the Heritage Lottery Fund have funded VTTP installations of the Brora Salt Pans, the 18th-century Fethaland Fishing Station Shetland Museum (90,000 visitors p/a), a model of 19th-century St Kilda World Heritage site, Taigh Chearsabhagh Museum (30,000), and the Eyemouth Fort Museum [S12]. The Vikingaminjar heritage company and the Cultural and Education director of Mosfellsbær are funding the University of St Andrews to reconstruct of a 10th-century Viking longhouse [S4] for use in schools and tourism.

Education and Schools At Madras College, the virtual *St Andrews Cathedral* informed the social science approach to a local unit of the Curriculum of Excellence, engaged Department of Assisted Learning students, and contributed to baccalaureate project work. The Head of DAS, Glenrothes High observed that *"these children with a range of moderate learning difficulties spend many hours on the X-box so the controls were recognisable and posed far less threat than paper and pencil… The pupils engaged fully with the activity and the arrangement allowed for co-operative learning, good oral communication skills and was fun" [S5].* A social science teacher commented *"The quality and quantity of work students have been doing in their own time speaks of how the Cathedral reconstruction has fired their imagination. I haven't known anything like it before"* [S2].

In a session with Dundee High students, all indicated it changed their impression of ancient Sparta: *"This session has now made me realise that they were more civilised than I thought. I liked the virtual world that showed what the church looked like"* [S9]. Describing a session in Linlithgow academy with the virtual Linlithgow Palace developed jointly with Historic Scotland and Education Scotland, the Education Manager for Emerging Technologies in Education Scotland observed *"each session lasting 40 minutes, buzzing with investigation, exploration, enthusiasm, and energy. Many pupils returned to interact further with the Palace during their own free time over lunch"* [S9].

TL to BR: In the digital Linlithgow Palace; Friends of Eyemouth Fort explore it in 3D using X-Box controllers and Oculus Rift; a descendent returns to Caen Highland Township with Timespan museum; words from Linlithgow Academy S2 describing Linlithgow Palace recreation.

A meeting with HM Inspectorate of Schools (10/2012) led to invitations to Royal High, the Scottish Association of Teachers of History Conference (11/2012), distribution through the pan-Scotland GLOW website (05/2013), and further school use including at Dundee High, Strathkiness Primary, Helmsdale Primary and Glenrothes High [S12]. Press and TV coverage [S6] with a total print circulation of over 200,000, has fed into online registrations (over 2000), web visits (20,000) from 112 countries, social media (8000 peak weekly reach) [S8]**,** and an invited feature in "History Scotland" reflect growing interest and influence. *"We see the support and partnership of those at St Andrews University as vital and influential in …our agenda of using contemporary digital tools and worlds to support, enrich and enhance learning"* [S1].

By creating immersive reconstructions with interactive content, windows onto the past have been opened which provide people with rich new insights into their cultural heritage. Existing and emerging digital literacies make the exhibits open to those with a huge range of interests and abilities. Internet access, portable exhibitions and installations enable access from home, in the classroom and in museums. Embedding exhibits in local museums reaches across generations and bring heritage to all parts of the community.

5. Sources to corroborate the impact

[S1] National Advisor for Emerging Technologies and Learning, Education Scotland. *Corroborates support of national priorities in education.*
[S2] Teacher, Madras College. *Corroborates student engagement.*
[S3] Chair of Board of Directors, Timespan. *Corroborates increase in visitor numbers.*
[S4] Projects director, Vikingaminr ehf. *Corroborates funding for overseas deployment.*
[S5] Head of DAS, Glenrothes High. *Corroborates educational experience.*
[S6] Press and TV reports. *Corroborates public engagement and positive commentary.*
[S7] Timespan Innovation of the Year. *Corroborates interactions with Timespan.*
[S8] OVW Web usage statistics. *Corroborates web site visitor profile.*
[S9] Exhibition and School Feedback. *Corroborates visitor engagement and enthusiasm.*
[S10] Create and Inspire report. *Corroborates activity and footfall at Dundee Science Centre.*
[S11] Digidoc documentation. *Corroborates significance of Digidoc exhibition.*
[S12] Virtual Histories letters of support. *Corroborates extension to different museums.*
[S13] Timespan User Evaluation. *Corroborates excellent user experience and comments.*