THE EVOLUTION OF DIGITAL PATRIMONY IN THE BUILT ENVIRONMENT

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The modelling revolution

In the late 1960s, the first tentative steps in the representation of three-dimensional geometry – digitally – was initiated. Pioneers in the field demonstrated that the form of three-dimensional (3D) objects, such as buildings, could be communicated by a series of points in 3D space, joined together to form lines, lines joined to form surfaces and surfaces joined to create volumes. By applying the mathematical laws of perspective geometry, so-called “wire-line” drawings were produced and, before long, the key to creating stereoscopic pairs of images was encoded. Figure 1 shows two computer-generated wire-line perspective images – possibly the first ever produced – about to be viewed through an early (circa 1880s) device manufactured and sold to facilitate stereoscopic viewing of matched pairs of carefully taken photographs, often of the Boer War. Figure 2 shows the modern equivalent – the Oculus Rift head mounted display – in which pairs of full-colour high-definition computer-generated stereo images are fed, at the frame-rate equivalent to commercial movies, to the right and left eyes of the viewer.

Fig. 1. An early stereoscopic viewing device with computer-generated wire-line stereo pairs of a building
Source: personal archive of the author.

Fig. 2. The Oculus Rift head-mounted display for dynamic stereoscopic viewing
Source: website of Oculus.
The Oculus and similar emerging technologies) accommodates the most recent ITC technologies that allow very fast changes to the left and right eyes to provide the user of the head-mounted display with an experience of full immersion in the virtual world as he/she moves his/her head in 360 degree space. Such technologies are transforming how we model, shape and evaluate future worlds; our concern here however, is how we re-create, understand and value our existing heritage and patrimony.

**Emerging technologies**

It took the architectural profession the best part of a decade (1960-1970) to realize and take advantage of the emerging information technologies; these – photorealistic imagery, dynamic energy prediction, simulation of movement, etc – are becoming commonplace in progressive architectural practice. It took considerably longer for those developing the technologies to anticipate and realize the application of the information technologies (IT) to our patrimony.

The Media Laboratory at the Massachusetts Institute for Technology, arguably, was the first to demonstrate the potential of what we now call “multimedia” – the conflation within one software environment of photographs, video footage, computer-generated images, sound, text, etc. What seems today a perfectly obvious development was – in the late 1970s – quite revolutionary.

Co-incident and subsequent IT developments led to the introduction of truly immersive “virtual” environments, as experienced in the Oculus Rift. Many different methods of allowing experience of 3D virtual worlds were developed including the Virtual Environment Laboratory (VEL) at the University of Strathclyde and the immersive facilities in the Digital Design Studio (DDS) at the Glasgow School of Art. In both of these, a number of people can simultaneously have the impression – as a result of surrounding visual and audio sensation – that they are within an entirely digitally created world.

Simultaneously there were developments afoot in how we can observe and record the existing world. Methods of achieving this include laser scanning. Laser scanning involve the “firing” of laser beams at 3D objects followed by a distance measurement based on the time the reflective beams return to the firing position. The mass of data captured – known as the “point-cloud” – can, with appropriate software, be interpreted as shapes of objects, buildings and/or landscapes. The technology can be deployed at various scales, from “flight-overs” of extensive landscapes to the fine-grain capture of small artifacts.

A parallel innovation, now an extraordinarily rapid development, was that of “rapid prototyping”. It was realized that the digital representation of 3D objects (including buildings) could – with a little difficulty – be deployed in a number of emerging electro/mechanical technologies – in the manufacture of scaled physical models of reality. The Department of Architecture at the University of Strathclyde was an early experimenter of how these new technologies could be put at the disposal of architects. Figure 03 shows, at two scales, rapid prototypes of the millennium tower, planned for Glasgow; Figure 4
shows the rapid prototype of a wooded roof truss, part of the structure damaged badly in the recent fire at the Mackintosh School of Architecture at the Glasgow School of Art. Currently, increasingly sophisticated but readily accessible devices can produce scale models in plastic, steel and ceramic.

**Fig. 3.** Two rapid prototype models of the Glasgow Millennium Tower produced directly from a CAAD data base
Source: personal archive of the author.

**Fig. 4.** A rapid prototype of a wooded roof truss, part of the structure damaged badly in the recent fire at the Mackintosh School of Architecture at the Glasgow School of Art
Source: personal archive of the author.

**Early applications**

In the author’s experience, the earliest applications of multimedia documents include those of Sabater in the University of Catalonia and Mortola in La Terza University of Rome. Sabater worked on the contribution of Cerda to the planning of the city of Barcelona and Mortola worked, in collaboration with the Commune di Roma, on the participation of the citizenry in the reformation of areas of the city of Rome.

The Architecture and Building Aids, Strathclyde (ABACUS), in association with SCRUN – the Scottish Cultural Resource Access Network\(^1\) built on its reputation for the early development of CAAD software to produce a number of innovative multimedia digital documents including Virtual Open Doors, Skara Brae, New Lanark and Glasgow 2000.

Virtual Open Doors (Fig. 5) is a CD-ROM that allows the user, interactively, to move around the interiors of some 50 of Glasgow’s most important (and not necessarily accessible) buildings. It takes advantage of what then (circa 1999) was software known as Quick Time Virtual Reality (QTVR).

Skara Brae (Fig. 6) is one of Northern Europe’s most extra-ordinary archaeological sites located on the Orkney archipelago off the north coast of Scotland. The unique features of this computer-based interactive exploration of the site include the embodiment of priceless artefacts found on site during the excavation in 1850 and “augmented reality” in which, regarding a hypothesis regarding the door mechanism, combines video shot on site with computer graphics animation.

New Lanark (Fig. 7) is a World Heritage Site developed in the 1880s by Robert Owen as a utopian vision of an industrial community, complete with a school, health care, etc. Owen went on to found the New Harmony utopian community in

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\(^1\) http://www.scran.ac.uk
the USA. SCRAN funded the double CD-ROM produced by ABACUS to record the rise, fall and re-generation of the New Lanark community.

The City of Glasgow was established following a visit by Saint Mungo (aka Kernogan) in the 6th Century. The interactive CD-ROM – Glasgow 2000 (Fig. 8.) is a massive digital document including 2000 words of text, 12 ancient maps, 5 video clips, 300 images, and a musical time-line spanning 1,000 years.

Recent applications

The innovative application of laser scanning to digital patrimony has been pioneered by a number of institutions including the Digital Design Studio (DDS) at the Glasgow School of Art\(^2\). The DDS, in association with Historic Scotland, has brought into existence what is known as the Scottish Ten. The Scottish Ten comprises a collaboration amongst the DDS, Historic Scotland, the Scottish Government, the Centre for Digital Documentation and Visualization (CDDV) and

\(^2\)http://www.gsa.ac.uk
CyArK, a USA company that specializes in laser scanning of world-class building and heritage sites.

Scottish Ten³ is an ambitious five-year project to create exceptionally accurate digital models of Scotland’s five UNESCO designated World Heritage sites and five international sites, in order better to conserve and manage them. The sites include: Mount Rushmore, New Lanark, Orkneys, Rani ki Vav, St Kilda, Edinburgh Old Town and the Eastern Qing Tomb.

A selection of these sites are described and illustrated in the following sub-sections.

Most people know of the extraordinary huge head/face/shoulder carvings of 4 previous Presidents of the USA. Figure 9 shows how perilous the scanning methods can be; Figure 10 is a composite image, featured in the National Geographic Magazine, showing the point-cloud representation, the geometric surface representation and the final textured digital representation.

Figures 11 and 12 show the scanning process and the point-cloud representation of the (now) deserted community of St Kilda – a tiny archipelago situated some 66 kilometres off the Western Hebridean islands of Scotland. The St Kilda community finally agreed to leave the main island in 1930.

³ http://www.scottishten.org
The Scottish Ten scanned Rosslyn Chapel in Scotland which famously featured in the novel The DaVinci Code by Dan Brown. Figure 13 shows the point-cloud associated with this project.

Figure 14 shows a wide-angle 3D digital image by the Scottish Ten of Edinburgh Old Town.

The issues

Digital patrimony is now properly established. In the superb Cumulative Index of CAD⁴ that contains over 11,000 abstracts and full papers on CAAD, there are no fewer than 218 papers with either “heritage” or “patrimony” in the title. There are now several international conferences on heritage including the second international conference on Digital Heritage to be held in Spain in September 2015⁵. Nonetheless, it is entirely appropriate to ask “why create and disseminate digital representations of our most important cultural heritage/patrimony”? The following sub-sections provide some answers to this question.

1. Our physical patrimony, regrettably, is worryingly fragile. The recent fire that destroyed the world-renowned library and invaluable records in C R Mackintosh’s Glasgow School of Art causes those responsible for the restoration to be grateful for the digital records prepared by the DDS and DiMascio. The recent destruction by the forces of the Islamic State in Syria cause us to regret not having captured, digitally, these treasures.

2. A detailed digital representation of man-made and natural phenomena, coupled with emerging IT for viewing, dynamically, 3D images, allows unprecedented opportunities for observing our heritage from hither-to impossible viewpoints. Effortlessly, we can climb Mount Rushmore, enter Wookey-hole, fly over remote sites such as St Kilda, Skara Brae, Ailsa Craig.

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⁴ http://cumincad.scix.net
⁵ http://www.digitalheritage2015.org
3. We have a new opportunity to combine the visual experience of our heritage sites with potential auditory experiences – to hear the wild gannets of Ailsa Craig, hear Mendleson’s Hebridean Overture while sitting in Fingal’s Cave, hear Bach’s Goldberg Variations while sitting in Utzon’s Opera House.

Nonetheless, there remains the big issue: to what extent does the actual relate to the modelled, how the digital relates to the analogue, how the “virtual” relates to the “real”. Big issues, it seems to the author, to pose to our students?

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