The Devil is in the Detail

Richard Laing   Jonathan Scott
The Scott Sutherland School of Architecture and Built Environment
Robert Gordon University: Aberdeen
Garthdee Road
Aberdeen
r.laing@rgu.ac.uk   *j.r.scott@rgu.ac.uk*

Aberdeen and Aberdeenshire, in the North East of Scotland, is unique in the quantity and quality of historic heritage, building and environments in existence and is now at risk. As exemplified by the likes of Historic Scotland's current signature project, "The Scottish Ten", high-definition scanning is a recognised method for the accurate portrayal of objects in 3-d digital environments. The technology is some of the most advanced in the built environment, yet the process of data collection is much simpler and quicker than more traditional methods of surveying. It is a powerful aid to the recording and future treatment of historic buildings and their environment. This study, as an exemplar, focuses on buildings of significant risk (of demolition or disrepair). These include examples of church and theatre architecture, where interior detail and mass are central to the design. The buildings studied are also notable due to the presence of large open volumes and decorative ornamentation, which would be extremely difficult to record through traditional surveying methods. High definition scanners collect a 'point cloud', which is assembled using scans taken from selected locations. The process followed in this study was similar to that reported previously in the literature (Barber et al. 2006; Arayici 2007, Brown et al 2008), where a range of techniques have been used to employ the resultant dataset within architectural modelling. The data provides an accurate geometrical record of a building or structure, and can be utilised within three dimensional surface modelling, visualisation of the built heritage, and potentially within rapid prototyping. The collection of this data will add significantly to our collective knowledge and, more importantly, can be digitally presented and disseminated more widely.

Heritage. Scanning. Surface models.

1. INTRODUCTION

This paper concerns the use of an emerging technology which enables the high definition recording of surfaces and environments. The technology itself was developed originally to help undertake recording of mainly industrial facilities, but the resulting data sets present challenging and fascinating challenges for the designer, artist, surveyor and archivist. Architecture is normally recorded within conservation studies in a manner somewhat akin to the practice of technical drawings, well suited to the subsequent design and application of construction work.

A specific practical benefit of using three-dimensional scanning is that the 'record' is far more detailed and accurate than is possible using more traditional surveying techniques. Where real additional benefits can accrue is through the possibility to manipulate, rotate, scale and visualise the data, to stimulate new ideas and new insights.

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historic heritage, building and environments in existence and now at risk. High-definition scanning is a recognised method for the accurate portrayal of objects in 3D digital environments, as exemplified by current work being undertaken by Historic Scotland (Scottish Ten 2011), and others. The technology is some of the most advanced in the built environment, yet the process of data collection is much simpler and quicker than more traditional methods of surveying. It is a powerful aid to the recording and future treatment of historic buildings and their environment.

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2. SCANNING

The high definition scanner is adept at scanning both internal rooms and spaces, and external environments. The laser has a range of approximately 200m, meaning that the equipment can capture surfaces and structures close to the scanner itself, and also the surrounding area. For example, undertaking a scan of a monument would also normally incorporate some record of other nearby objects or physical features, including roads and natural features such as trees.

The advantage of scanning internal environment using the HD scanner is simple – it can reach places which normal survey techniques cannot reach. This may include, for example, double height spaces and roof spaces. This is particularly useful for internal spaces which are in use. The HD scanner can pick out objects not easily within reach (i.e. light fittings, pipes, etc) and also detail accurately decorative mouldings (i.e. architraves).

The case study illustrated in later figures collected geometrically accurate data pertaining to a partly intact sandstone castle located in rural Aberdeenshire. The scanner was assembled at numerous locations both inside and outside the structure, ensuring that details such as the boundary wall were captured (see figure 3, for example). The process followed was similar to that reported previously in the literature (Arayici 2007; Barber *et al* 2006), where a range of techniques have been used to employ the resultant dataset within architectural modelling.

Figure 1: Scanner in operation

The process itself, although producing a three-dimensional visual representation of objects, operates quite differently to modelling processes normally followed using 'additive' software such as AutoCAD or 3DS. In such software, buildings are virtually 'constructed' in empty space, with the designer initially adding objects and shapes to create the illusion of real material.

HD scanners, conversely, operate by identifying where points lie on a surface, and effectively work by 'hollowing' space around the scanner head (Smits 2011).

The most obvious immediate uses for such scanned output are twofold. Firstly, a far greater level of accuracy can be expected when taking measurements from the model than would ever be possible undertaking manual surveys on site. Secondly, and perhaps of most relevance to this study, is the potential for using such surveys to identify and record accurately the existing structure. Although in the case of the Tivoli the auditorium is intact and remains in much the same condition as it has been for many decades, many other cinema buildings have been subdivided over time and details removed or altered. A potential use of this

emerging technology should be to facilitate a virtual reconstruction of altered buildings, using measured 'clues' from the site.

2.1 Method

Given that the scanner operates by using laser light to contact millions of points during a scan, the equipment is limited by its initial placement (as blocked areas appear as 'shadow'). Therefore, most scanning sessions incorporate more than one position, each of which can then be retrospectively connected (registered) to provide a more holistic record. Previous studies undertaken (Laing and Scott 2011) concerning the recording of cinema interiors illustrated specific but not untypical challenges, given the overlap of horizontal spaces created by balconies. These challenges are similar to those presented by internal walls, areas of decoration, or immovable objects.

Figure 2: Scan taken from a theatre/cinema study

This is also well illustrated in figure 2, which shows how the interior shape of the auditorium has been picked out by the scanner, leaving the internal content of the balconies hidden. What figure 2 also illustrates very effectively is that the nature of the scan itself tends to present environments in a rather stylised or abstracted manner, presenting spaces as vessels, or from angles not normally viewed in reality.

A practical consideration for users in wetter climates is that whilst the scanner does not require areas to be lit, relying on the laser itself, the equipment cannot operate in rain. This is due to the laser making contact with the individual rain droplets, rather than the intended surface to be recorded. Similarly, scanning equipment tends to encounter problems recording reflective surfaces such as windows, as the lasers may be deflected by the target surface itself.

2.2 Data

Point clouds using the HD 3000 Leica scanner are rendered in 'intensity', which provides the vivid reds, greens and oranges in the pictures on the left. An example taken from the building interior is shown in figure 3.

Figure 3: Scan showing intensity data

Once rendered into the operating environment (called 'cyclone') the point clouds can be edited, added-to or deleted. This therefore facilitates the possibility in some instances to re-create once hidden building elements, or to delete current objects to undertake line-of-sight studies.

Figures 4 and 5 illustrate how the data set, regardless of the original scanner location, can be viewed from whatever angle best suits the study to hand. The location of the scanner used to collect data for figure 5 can be identified by the black circle, which is the closest circle scanned around the tripod. That this manipulation of the data is readily available for viewing immediately after the scan has been completed (and, in fact, during), allows the user to explore viewpoints not normally available. Figure 4, below, illustrates how a scan taken from the floor of the interior can be used to view plan shape and wall details from above.

Figure 4: Scan detail showing aerial view

Figure 5: Point cloud showing a building plus its boundary wall

Figure 6: Comparable site photograph

Figure 7: Scan image including photographic rendering

3. DISCUSSION AND APPLICATIONS

The most obvious immediate uses for such scanned output are threefold, and relate to accuracy, surveying and the creative arts.

Firstly, a far greater level of accuracy can be expected when taking measurements from the model than would ever be possible undertaking manual surveys on site. This means that information recorded during a scan will accurately reflect the overall physical environment, as well as the specific building, object or other structure being considered. The data 'point cloud' itself becomes an instant record of the site at a point in time, which could be used in the future to study surface changes, or as part of a design process exploring the impact of new design on a space.

Secondly is the potential for using such surveys to identify and record accurately the existing structure. The structure considered here is largely derelict, yet the walls contain many clues as to the original construction, including the position of walls, floors and details. Many are impossible to survey using other surveying techniques, and the data can accurately assist in the development of new and highly detailed work. The effects of climate change on buildings are such that accurate and regular monitoring of surface condition and characteristics could prove extremely useful. Less than 5% of any buildings or monuments of historical note in the Aberdeenshire have ever been recorded in detail, and those which have were recorded using dated surveys. Scanning provides a quick and simple way to capture data that you may then utilise at any time in the future

Finally, there is clearly potential for direct application within architectural and other design work. An important point to make is that many point clouds can only be readily understood and correctly perceived when actually rotating or moving, due to complexities caused by overlaying many millions of data points. The ability of rapidly view environments from perspectives not otherwise available to the designer holds potential within the conceptual design stages, and suggests a possible route through which IT can genuinely assist in the generation of new design concepts (as explored by Salman *et al* 2008).

4. CONCLUDING REMARKS

A key point when considering any method of information visualisation is the result of looking at a

diagram, picture, image or data resource (Spence 2007). Data clouds such as those illustrated in this paper offer the chance to explore architecture in ways which are not possible using traditional methods of either recording, surveying or modelling. Future research, it is suggested, could usefully explore how point clouds can be readily incorporated within the regular design process. Industry standard modelling packages including AutoCAD now support the inclusion of point clouds within architectural 3D models, yet manipulation of such data remains difficult without dedicated software. Therefore, there would appear to be opportunities and challenges related to a cross-disciplinary study of the implications for design, IT and visualisation of architecture and architectural heritage.

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