

Chapter 2

More Than Just a Sum of the Points: Re-Thinking the Value of Laser Scanning Data

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Abstract High-definition laser scanning is becoming increasingly popular within the field of heritage, with applications ranging from the digital recording and analysis of landscapes to buildings and objects. In some ways the uptake of this technology reflects new ways of addressing old questions, but with the potential for greater accuracy and density of spatial information. Through the exploration of three case studies, this chapter highlights the additional value that laser scanning can bring to heritage applications, with each example showing how the re-tasking of the captured data can result in additional benefits that extend considerably beyond the initial intentions. It is argued that, unlike the results from more conventional survey methods, high-definition laser scan data can exist independently from the original intentions of the survey and that it holds considerable value for addressing previously unimagined possibilities.

Keywords High-definition survey · Laser scanning · Re-tasking data · Museums · Conservation · Presentation

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2.1 Introduction

The potential of high-definition laser scanning survey has been demonstrated within the field of heritage for its ability to capture highly detailed and accurate information regarding surfaces of objects, structures, buildings and landscapes. At its broadest level, airborne laser scanning (LIDAR—Light Detection and Ranging) has provided opportunities to generate highly accurate, high-resolution models of entire landscapes (e.g. Crutchley 2006), with the ability to map the topography of land surfaces even through dense tree cover (e.g. Doneus et al. 2008). At a terrestrial level, laser scanning has provided the opportunities to record built heritage at high accuracy and at dense resolution both on its own (e.g. Rüter et al. 2009) and in combination with other techniques (e.g. Al-kheder et al. 2009). At the object scale, laser scanning has been applied to the interpretation of artefacts and to the objective documentation of metric data, such as physical dimensions with the potential for using outputs to derive further information. For example, a study of Palaeolithic axes used the results of laser scanning to determine objective and systematic measurements that could be used in documentation and interpretation (Grosman et al. 2008). Similarly, a study focusing on the scanning of ceramics was aimed at extending metric analysis through measuring factors including the rotation axis of wheel thrown pottery (Karasik and Smilansky 2008). In some cases, similar approaches have been used to generate reference collections as aids to assessment and interpretation of material such as faunal remains (e.g. Niven et al. 2009).

It has been noted that “metric survey forms the base map upon which our conservation actions are planned and recorded: mapping the historic environment helps us to understand, manage and enjoy it” (Andrews et al. 2009, p. 1). However, despite the development of laser scanning as a method for capturing high-definition, high-accuracy datasets, the metrical description of an object, building or landscape is not in itself an act of interpretation (Gaffney 2008). Hence, the real potential of the data derived from laser scanning surveys lies in its facility for re-tasking that enables it to address multiple challenges at once. For all approaches of high-definition survey, including laser scanning, the output provides an archive of data that could be re-used in the future, both in terms of documented interpretations, but more importantly the scan data itself. The real value of the use of high-definition survey rests in the way in which data that was perhaps generated for a particular purpose can be re-tasked for additional purposes.

In this chapter, we present three case studies from the work of the VISTA Centre at the University of Birmingham. Each project focused on the collection of high-definition laser scan data in order to achieve a specific aim. However, in each case, the benefits of the resulting laser scan data have extended beyond the initial aim, including raising new questions and opportunities. Together the projects demonstrate the potential added value of high-definition data through its re-tasking for a range of additional purposes that extend from archiving, analysis, interpretation and accessibility and public presentation. The first example centres on the generation of high-resolution models of artefacts for the generation of a virtual

museum with the aim of providing accessibility to wide demographics via the Internet. The second example focuses on issues of conservation regarding wet-preservation of organic artefacts and the implications for their future management and archiving. The final example concerns built heritage and the value of laser scanning as a tool for virtual preservation, but with added benefits of re-tasking the data for use by architects and for public communication. Together we argue that these examples demonstrate how the capture of high-definition data enables new ways of engaging with heritage at a range of levels.

2.2 Eton Myers Collection Virtual Museum

Museum collections provide excellent opportunities for both the study and public accessibility to the past. There remain certain challenges in that large proportions of collections are never on display, and that the public are separated from objects for the obvious reasons of fragility and economic value. However, perhaps one of the greatest challenges is the physicality of museum collections in that they need to be visited in person in order to experience the objects contained within them. However, there have been considerable attempts to embrace digital technologies and the Internet to, in part, address this challenge and so it has been noted that, “more and more the mnemonic function of the museum is given over to the electronic archive, which might be accessed almost anywhere” (Foster 2002, p. 95).

For the Eton Myers Collection, the challenge of accessibility was significant. This collection of ancient Egyptian art was bequeathed to Eton College, UK, at the end of the nineteenth century by Major William Joseph Myers (1858–1899) who had been a pupil at Eton during the 1870s. His military career as an Aide-de-Camp to the General commanding in Cairo led Myers to first visit Egypt in 1882 where he became interested in ancient Egyptian and Islamic art, and soon distinguished himself as one of the most important private collectors in Egypt. When he died in 1899, Myers bequeathed a collection of approximately 1,300 objects to Eton College, and these collections were subsequently supplemented by objects from el-Amrah, excavated by the Egypt Exploration Fund (1989–1899), prehistoric flint implements donated by the British explorer Seton-Karr and matching objects presented to the collection by Percy E. Newberry during the 1930s, including objects from Beni Hasan. Minor gifts followed (Reeves 1999), and in 2007 a major donation, the Peter Webb and Ron Davey Collection, was handed over to Eton College. It is estimated that there are currently at least 3,000 objects in the collection.

The demonstrable international significance of the collection for scholarly study has been tempered by lack of access, which is augmented by a lack of a complete catalogue or publication about the objects. Hence, in 2008, through collaboration between Eton College and the University of Birmingham, a programme of three-dimensional (3D) digitisation of the objects commenced, funded by the Joint Information Systems Committee (JISC). The primary aim of the project was to

address issues of access by making parts of the collection accessible to the broadest possible demographic via the Internet as a virtual collection that could be useful to everyone, from the interested public, to schoolchildren and teachers, through to Egyptological specialists, thus providing a scalable range of need from basic imagery, to interactivity, to the potential for accurate metric analysis. The method chosen for this was laser scanning.

The scanning of the collection used a tripod mounted Konica Minolta Non-Contact 3D Digitiser VIVID-910 which provides relatively short range (most accurate between 0.6 and 1.2 m) but records positional information including colour rapidly and at a high accuracy (± 0.22 mm (x), ± 0.16 mm (y) and ± 0.10 mm (z)). In addition, a selection of the objects was scanned using a NextEngine 3D HD Scanner (2020i) at an accuracy of ± 0.13 – ± 0.38 mm at a target surface resolution of 400DPI–150DPI. Both scanners use a triangulation method (using two fixed points on the scanner to determine the 3D position of the reflecting laser light on an object) to provide large quantities of highly accurate data. The 3D nature of the objects meant that it was necessary to scan each item from numerous angles to eliminate any chance of holes in the data and to minimise ‘shadows’ or ‘striping’ in the surface colour of the final model (caused due to inescapable variations in lighting). The scans for each object were registered together and archived as raw ‘point clouds’, before being meshed and cleaned using Geomagic software to provide continuous 3D models. These two outputs (point-cloud and mesh) form the objects that are curated as the high-resolution *Virtual Museum*, each with a file size of between 500 MB and 3 GB (Fig. 2.1).

For online delivery, the sheer file-sizes of the high-resolution models meant that they need to be decimated to a smaller size and converted to a format appropriate for web delivery. Each model was reduced within the Geomagic software and exported to Wavefront OBJ format. This is a simple ASCII-based format that is

Fig. 2.1 Photograph, colour 3D model and colour-stripped, artificially lit model of a shabti from the collection. This item has a hieroglyphic text encircling it and requires the object to be turned to be read



widely supported by most 3D modelling packages, and due to the ASCII representation, the model data lends itself to substantial file compression (approximately 60 %) reducing network transmission time if this is critical. Under this format Geomagic exports texture information in an accompanying material (MTL) file, which is an extension to the OBJ format. The texture images themselves are exported in the common Joint Photographic Experts Group (JPG) graphics format.

For hosting the online presence for the virtual museum established museum software was used. Willoughby MIMSY XG software that is used for online collections such as the British Museum was used to host the collection. However, whilst the software and supporting database is able to host a wide range of media, 3D models cannot be uploaded onto the system. For these models a download site was created to obtain models in a higher (typically between 10 MB and 25 MB) and lower resolution format which could be opened in a range of viewing software packages such as Meshlab.

For the virtual museum, the 3D objects were accompanied by an online catalogue including provenance (where known), interpretative and other information collated by a team of Egyptologists. The resulting online resource (http://www.vista.bham.ac.uk/3D%20LS/Eton_Myers.htm) provides access to the collection which includes photography, interpretation and the facility to download the OBJ files for the 3D models at two different sizes. Future resilience is provided by the archived high-resolution data from which new, higher resolution OBJ files can be processed, although these models remain accessible on request through the University of Birmingham. In addition to providing an online resource, the project also highlighted some of the advantages and disadvantages of laser scanning for the documentation of different materials, and in particular specific differences between the two different laser scanning approaches used.

The resulting dataset provides curation of a digital museum which is not now represented physically as a single collection (Chapman et al. 2010). The raw data in some way equates to the museum store, where the (virtual) artefacts are stored and looked after for the future. The various levels of decimation of these datasets for various levels of online delivery provide a more accessible series of objects, perhaps akin to museum displays, but with the added value of enabling interaction and metric analysis from anywhere in the world.

However, whilst the original purpose of the data capture was to do just this, providing unlimited access to an otherwise inaccessible heritage resource for a broad demographic, in practice, the resulting dataset has provided considerably more. The scan data provided a point-in-time record of the objects such that they are conserved for the future, albeit in a digital format. More specifically, the high-definition datasets provides a new way of seeing the objects—effectively enabling scholars to see the invisible. For some objects, cultural analysis was easier using the virtual object than the physical ones, due to the ability to zoom in, to remove colour information, to exaggerate surfaces and to alter lighting. This enabled text on some objects to be seen more clearly (Fig. 2.2) and, for one of the paintings, it revealed the initial sketching out of the image which was done by scratching into the wooden board (Fig. 2.3).

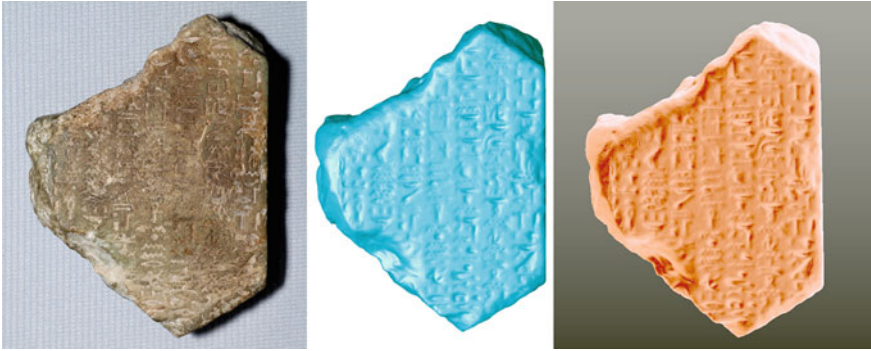


Fig. 2.2 Photograph of one of the objects (*left*) with various surface analyses of the laser scanned model to highlight inscriptions

The laser scan data also provided new possibilities for engagement with these museum objects themselves, both virtually, such as through haptic interfaces, and physically, through digital 3D rapid prototype printing. The potential of rapid prototypic might also offer economic value, such as through the facility of print on demand. These new ways of engaging with objects offer exciting opportunities for

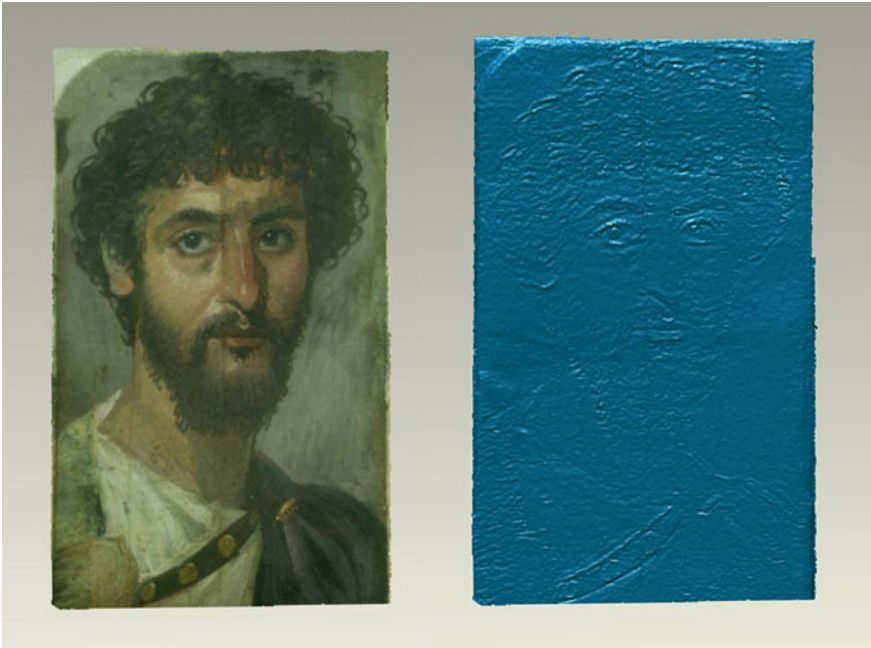


Fig. 2.3 Photograph and colour-stripped, artificially lit 3D model derived from laser scanning data. The 3D data reveal both the depth of paint in the image and the indentations relating to the initial sketching of the image prior to painting



Fig. 2.4 3D scan and rapid prototype model of a mummy's hand wearing a faience ring. These technologies, along with approaches such as haptic interfaces, bring new opportunities for engaging with and handling fragile objects such as this

providing access to the collection, for example, for school groups and for users that are visually impaired which would not normally be feasible due to the fragility of some of the objects (Fig. 2.4).

2.3 Wet-Preserved Archaeological Wood

This second case study focused on issues of heritage conservation of fragile, unstable objects. In the case of organic materials, long-term preservation is a result of very specific conditions relating to their burial environment. Once these environmental conditions are altered, the processes of organic degradation are accelerated and so the object will deteriorate along with its potential to provide valuable

information. One context where organic material can be exceptionally well preserved is within wetlands (*cf.* Coles and Coles 1986; Christensson 2004; Field and Parker Pearson 2003; Lillie and Ellis 2007; Van de Noort et al. 2007). In the UK and Europe, agencies concerned with heritage protection have a stated objective of preservation of archaeological remains *in situ* (Department of Environment 1990; Willems 1998). However, for wetlands, changing factors including groundwater levels, flowpaths and geochemistry mean that the long-term stabilisation of archaeological sites and artefacts *in situ* might not always be feasible (e.g. Brunning et al. 2000; Gearey and Chapman 2006; Gregory and Jensen 2006; Holden et al. 2006; Kenward and Hall 2000; Modugno et al. 2008; Van Heeringen and Theunissen 2002; Van de Noort et al. 2001) leading to the need for *preservation by record* through excavation. However, the removal or wet-preserved organic artefacts from their burial environment provides challenges for the storage, analysis, stabilisation and preservation of these objects which become threatened by both deformation through water loss and degradation through fungal and microbial activity (Grattan et al. 2006; Lillie and Smith 2007; Jiachang et al. 2009).

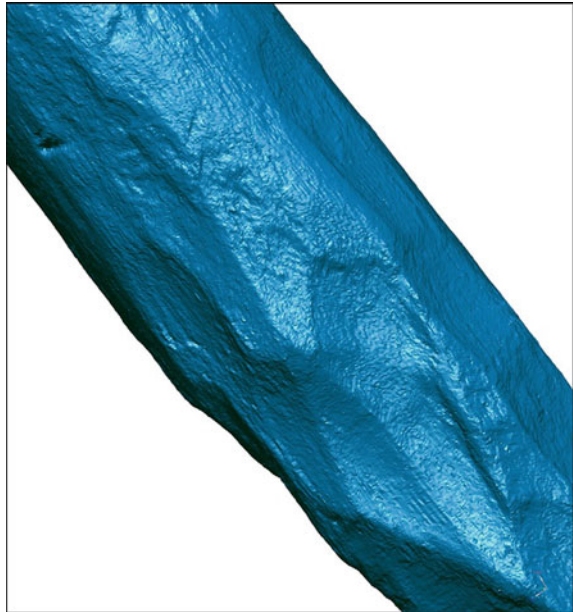
The most common material recovered from waterlogged contexts is anthropogenically modified wood, ranging from single artefacts (Morris 2000), to sewn plank boats (Wright 1990; Clark 2004), fishtraps (O'Sullivan 2005) and bridges (Salisbury 1995), with some sites yielding significant quantities of wet-preserved wood, such as from Fiskerton in Lincolnshire (Field and Parker Pearson 2003) and Flag Fen in Cambridgeshire (Pryor 2002), both in the UK. Organic, wet-preserved archaeological material presents considerable difficulties in terms of post-excavation recording, analyses and stabilisation. Upon exposure, water infilling the pore space capillaries within the wood will drain away or evaporate, unless the degree of saturation is maintained through total immersion in water (Brunning 1995; English Heritage 2002; Watkinson and Neal 1998). The time that elapses between excavation and analysis may be considerable and short-term storage solutions usually involve refrigeration or wet tank storage.

Archaeological recording of wet-preserved wood will typically include the measurement, description, photography and scale drawing of samples. At the most basic level, the analysis of tool marks from archaeological wood requires the measurement of the surviving tool signatures on the wood. However, due to the expense of long-term stabilisation of the material, it is often the case that only 'exceptional' wooden artefacts are retained for permanent preservation. Photography and 'signature matching' software has been used to record and compare tool signatures on waterlogged wood with some success (Sands 1997, p. 30), though the technique has not gained widespread use and would benefit from further research. The potential for deformation of wet-preserved archaeological wood within different storage conditions is unclear due to the difficulties in measuring change volumetrically, but an understanding of these processes is fundamentally important if we are to understand the validity of metrical analysis on these timbers following prolonged periods of storage.

Hence, a pilot project was established to examine the potential for deformation of wet-preserved archaeological wood within different storage conditions (including those most strongly recommended; *cf.* Brunning 1995; English Heritage 2002; Watkinson and Neal 1998). In addition to conventional recording (Van de Noort et al. 1995), the focus was on scanning the objects immediately after excavation and then again following storage under different conditions to enable comparison between the scans that might identify deformation in the wood. A total of seven pieces of wet-preserved archaeological wood were selected for analysis from the site of a Saxon fish weir within an infilled palaeochannel of the River Trent in Derbyshire, UK (Krawiec 2008). These seven stakes were digitised using a Konica Minolta Non-Contact 3D Digitiser VIVID-910 laser scanner, as used for the Eton Myers Collection outlined above, to establish a vertical resolution of about 0.4 mm with a lateral point accuracy of ± 0.3 mm—a high level of point accuracy which was needed since change between different scans could only be detected outside of the range of twice the point accuracy of the equipment (Fig. 2.5).

Following their initial scanning, the seven pieces of wet-preserved archaeological wood were stored in a variety of different conditions; two were immersed in a tank of water, two were placed in refrigeration, two were stored in a freezer and one was wrapped in plastic and stored at room temperature to provide a ‘control’ sample. All of the pieces were then rescanned using the same settings after a period of 1 month, and then the two scans of each object were compared to assess changes in morphology. Variations within the range of ± 0.4 mm were

Fig. 2.5 Detail of a model derived from laser scan data of toolmarks on one of the stakes



discounted as they could not be validated due to the measuring tolerance of the instrument.

The detailed results of the comparative analysis have been published separately (Lobb et al. 2010), and show that all samples underwent some change within the first 4 weeks of storage, but that the degree of change did reflect the storage environment. The stake wrapped in plastic suffered significant distortion with a change in diameter at its widest point from 83.5 to 48.7 mm. Frozen samples swelled up by up to 2.7 mm across each face, which can probably be attributed to the expansion of water within the individual cells of the wood (Fig. 2.6). Refrigerated samples showed little change overall, although ridge detail and the tips of both samples suffered loss of definition, with shrinkage of up to 1.5 mm. The two samples stored in water revealed the least amount of change, although shrinkage was identifiable especially around ridges and ends by up to 1.5 mm per face.

Alterations in the morphology of objects appear to reflect distortion due to changes in saturation rather than degradation through fungal or bacterial action. The results confirm that, in the short-term at least, storage in wet-tanks is the most appropriate approach. However, the identification of morphological changes within a short time period, even within wet-tanks, indicates the potential for lost information that can be gained from subsequent post-excavation analyses such that

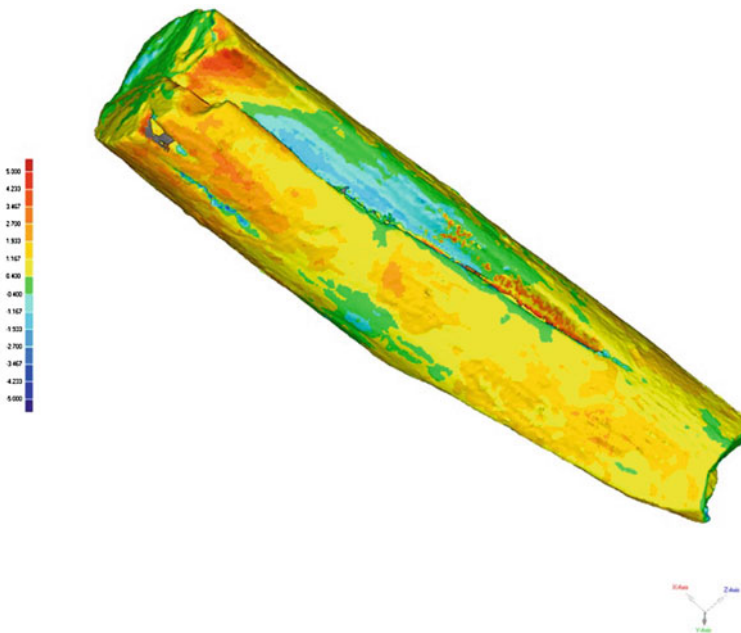


Fig. 2.6 Comparative analysis of one of the stakes stored in the freezer. The *red* and *blue* areas reflect expansion and shrinkage in the object, respectively, following one month of storage

metric recording and demonstrates that such recording should always take place as soon as possible following excavation, regardless of storage conditions. Furthermore, for the long-term archiving of material, this work demonstrated the limitations of physical storage, at least for metrical analysis. Whilst storage facilitates other forms of analysis, such as species identification and scientific dating, for the metrical analysis of tool marks, laser scanning provides perhaps the most effective solution since it preserves an accurate record of the object which can enable future measurements and analyses, in addition to adding to an archive that might be used for approaches such as ‘signature matching’.

However, whilst this project was aimed at exploring issues of conservation, it highlighted the potential for using scan data as an alternative method for generating an archive of wet-preserved archaeological wood which, for metrical analysis at least, provides a more sustainable and reliable dataset than the physical objects themselves. Furthermore, the more accurate capabilities of virtual objects for metric measurements, in addition to the ability to provide access to these datasets digitally to specialists anywhere in the world, highlights the value of this data for heritage needs more broadly. Once captured, such data also provides opportunities for public display, either digitally, or through 3D rapid prototype printing which preserves the volumetric accuracy of the objects which is unlikely to be the case for most methods of conservation for waterlogged organic remains (*cf.* Unger et al. 2001).

2.4 The National Public Housing Museum, Chicago

The first two examples explored the different uses of laser scanning data in terms of the heritage of objects. In this final case study, the application of laser scanning technologies to the recording of upstanding built heritage is presented. In 2013, the last remaining building of the Jane Addams Homes public housing development in Chicago will be converted into a museum dedicated to the interpretation of the experience of public and social housing in North America and globally, particularly focusing on the resilience of poor and working class families from across all races and ethnicities. This ambitious project, directed by Dr Keith Magee, will create the National Public Housing Museum (NPHM) which will be the first cultural institution in the United States dedicated to interpreting the American experience of public housing, in addition to providing a study centre focused on housing policy, an exhibition space, recreations of apartments from different decades from the twentieth century and an interactive area for learning about new visions for sustainable neighbourhoods (www.publichousingmuseum.org).

The building itself was constructed as one of a series of tenement blocks built under the Public Works Administration Act from the 1930s aimed at creating jobs and relieving the Depression era economy. The first large public housing project in the world (Hatch 2012, p. 11), it was designed by a team of architects led by John Holabird in 1932, and named after the 1931 Nobel Prize winning founder of

Chicago's Hull House, Jane Addams. The Jane Addams Homes provided housing, child care, employment counselling and a range of other social services including education (Deegan 1990). The building was occupied by successive generations until 2002, with a series of different communities occupying it at different times. In 2006, the building was saved from being knocked down, and remains as the last of the Jane Addams Homes.

There remained something of a paradox. Whilst the building was being saved from total destruction due to its future role as a public space, in order to create the museum, parts of the building would need to be renovated and altered. Therefore, it was considered fundamentally important to capture as much information about the building prior to any works that might alter it; to preserve the building virtually so that the important moment of transition from the end of its earlier existence as a tenement block and the start of its new life as a museum. It was decided that the best method for preserving the current fabric of the building was to record it digitally using laser scanning. Hence, through collaboration between the NPHM and the University of Birmingham, the VISTA Centre set to record the building in detail prior to its transformation.

Laser scanning was considered the most appropriate method for the capture of data from the structure since it provides a high density of data at a high resolution and of considerable accuracy. For the project, a terrestrial scanner was used: the Leica ScanStation C10, providing an overall resolution of ≤ 0.4 mm and operates with a range of 0.2–c.300 m. The complexity of the tenement block structure, and the large number of apartments and small rooms contained within it, meant that numerous scans were needed, linked together by shared targets that could be seen from separate surveys. A total of 142 separate scans were collected with a total of around a billion data points represented in the final, merged point-cloud (Fig. 2.7).

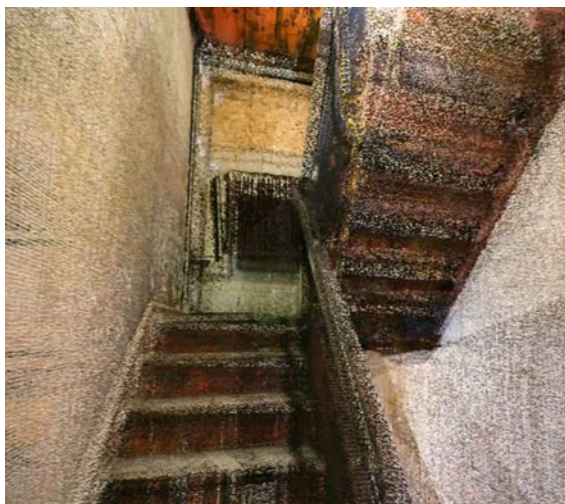
The aim of the laser scanning project was to capture detailed information about the structure of the building as a point-in-time record of the final stage of its life as public housing, to provide a virtual version of the building preserving it digitally for the future. The scan data does this extremely effectively, and it is possible to see features such as the purposefully created holes in walls between apartments enabling movement between them, perhaps for nefarious purposes such as police evasion, and other features such as the stairwells (Fig. 2.8). It also captures the shape and detail about these spaces as homes.

At one level, therefore, laser scanning of the NPHM has provided a detailed record of the building; a virtual preservation prior to its transformation into a museum. However, since this work was completed in October 2012, the potential of this data has been realised far beyond initial expectations. A video showing a fly-through of the building has been placed on the NPHM website, providing a simulation of the building as an object that can now be accessed from across the world, significantly raising the profile of the project. Furthermore, the architects designing the transformation of the building into a museum have demonstrated a strong interest in using it in their work, due to the high metrical accuracy which by far exceeds the potential of existing plans and elevation drawings. For the future, the laser scanning data also provides a means of accessing the public housing at



Fig. 2.7 Point-cloud data of the exterior of the National Public Housing Museum

Fig. 2.8 Detail of part of the interior of the building



the end of its life using interactive technologies such as serious gaming. The potential of such an approach, in addition to the possibility of using the data as a foundation for reconstructing earlier homes within the building at different times, will most likely become a feature of the exhibition space within the museum when

it opens, allowing visitors to explore the earlier phases of the structure. Hence in addition to the initial aim of virtual preservation of a specific point-in-time in the building's life, it has also become a tool for public dissemination, for architectural design and will form part of the future exhibitions within the museum when it opens.

2.5 Discussion: A Paradigm Shift in Survey?

This chapter has briefly presented three of the vast number of scanning projects undertaken by the VISTA Centre at the University of Birmingham. In each case, the aim of the project was specific, with the choice of laser scanning as a methodology being determined by this specificity. However, in each case, the resulting point-cloud data provided considerable, sometimes quite unexpected opportunities for its re-use, addressing other priorities. The Eton Myers Collection Virtual Museum project was aimed at providing accessibility to an otherwise inaccessible museum collection across a wide demographic, but resulted in a point-in-time record of the objects in addition to opening the exploration of novel ways of engaging with 3D digital data through haptic interfaces and 3D rapid prototype printing and the implications for accessibility to other groups, such as school groups of the visually impaired, through other senses such as touch. The models also provided useful tool for the analysis of the artefacts, such as through the ability to exaggerate surfaces, control lighting conditions and to remove colour textures to enable new discoveries to be made and, as such, are beginning to drive new approaches to the research of these objects. Ultimately, the project raised new questions about what a virtual museum could actually be.

In contrast, the laser scanning of wet-preserved archaeological wood was aimed at exploring methods of conservation through the comparison of highly accurate models of wooden objects directly after excavation and following different methods of storage. The project highlighted best practice, but also demonstrated the value of scan data for metrical analysis and its potential as an alternative approach to recording tool marks on these objects. Furthermore, the project highlighted implications for the conservation of wet-preserved wooden objects as an archive and for museum display, indicating that, in terms of the preservation of metrical accuracy, laser scanning offered a significantly improved solution compared with current approaches to the physical conservation of these objects.

The final example centred on the notion of *preservation by record*, through the high-definition recording of an historically significant building prior to its transformation into a museum. In addition to providing a high-resolution point-in-time record of the building, the scan data has also demonstrated considerable value when re-tasked as a tool for public engagement due to the ability to enable people across the world to experience the structure virtually. It is currently demonstrating the value of re-using data for the architectural process of renovation and

transformation into the museum and, in the future, the data will be re-tasked again to provide a part of the exhibition on the past life of the building.

The value of high-definition data capture approaches such as laser scanning is in part due to its ability to rapidly collect high resolution, highly accurate data about the surface of an object, structure or landscape. However, the data itself provides additional values. More traditional approaches to survey were aimed at capturing data at a particular scale or resolution. For example, in archaeology, excavations are commonly recorded using plans and section drawings recorded at scales ranging between perhaps 1:10 and 1:50, whilst earthwork surveys might be surveyed at scales of between 1:250 and 1:25,000 (*cf.* Bowden 1999). These standard practices reflect the processes of recording, the perceived needs of the resulting archive and the potential scales of reproduction in reports and publications. With high-definition survey, the paradigm has arguably shifted. For the first time, the potential for capturing data at a higher resolution than that required for the vast majority of outputs means that survey resolution is no longer dictated by the scale of a drawing, but by the capabilities of the equipment (assuming that it is sufficient for purpose, as explored with the laser scanning of wet-preserved archaeological wood discussed in this chapter). For the first time, the capture of data is not determined solely by the intended outputs; the resulting datasets from high-definition survey normally require some level of decimation or generalisation, although this need is likely to reduce with increases in networking technologies. Hence, the captured data exists independently from the original intention of the survey, and this highlights its tremendous potential for re-tasking.

The three examples discussed in this chapter demonstrate this potential for re-tasking data, and the capability of high-definition survey data to address new ambitions following its capture. Whilst it is important to always critically assess the usefulness of data when applying it to a purpose for which it was not originally collected, high-definition survey represents a new way of thinking about recording heritage which is less reliant on the intentionality of the original survey. It provides a tool for capturing data that can be used and re-used for all stages of heritage processes, from archiving through to conservation, interpretation, public access and re-presentation.

References

- Al-kheder, S., Al-shawabkey, Y., & Haala, N. (2009). Developing a documentation system for desert places in Jordan using 3D scanning and digital photogrammetry. *Journal of Archaeological Science*, 36, 527–545.
- Andrews, D., Bedford, J., Blake, W., Bryant, P., Cromwell, T., & Lea, R. (2009). *Measured and drawn techniques and practice for the metric survey of historic buildings* (2nd ed.). Swindon: English Heritage.
- Bowden, M. (Ed.). (1999). *Unravelling the landscape. An inquisitive approach to archaeology*. Stroud: Tempus.

- Brunning, R. (1995). *Waterlogged wood: Guidelines on the recording, sampling, conservation and curation of waterlogged wood*. London: English Heritage.
- Brunning, R., Hogan, D., Jones, J., Jones, M., Maltby, E., Robinson, M., et al. (2000). Saving the sweet track. The in situ preservation of a Neolithic wooden trackway, Somerset, UK. *Conservation and Management of Archaeological Sites*, 4, 3–20.
- Chapman, H. P., Gaffney, V. L., & Moulden, H. (2010). The eton myers collection virtual museum. *International Journal of Humanities and Arts Computing*, 4, 81–93.
- Christensson, A. (Ed.). (2004). *Safeguarding Historical Waterfront Sites Bryggen in Bergen as a Case*. Norway: Culture 2000.
- Clark, P. (Ed.). (2004). *The Dover Bronze Age Boat*. Swindon: English Heritage.
- Coles, J. M., & Coles, B. J. (1986). *Sweet track to Glastonbury: the somerset levels in prehistory*. London: Thames and Hudson.
- Crutchley, S. (2006). Light detection and ranging (lidar) in the Witham valley, Lincolnshire: An assessment of new remote sensing techniques. *Archaeological Prospection*, 13, 251–257.
- Deegan, M. J. (1990). *Jane Addams and the men of the Chicago School, 1892–1918*. Somerset: Transaction Publishers.
- Department of the Environment (1990). *Archaeology and Planning. Department of the Environment Planning and Policy Guidance 16*. London.
- Doneus, M., Briese, C., Fera, M., & Janner, M. (2008). Archaeological prospection of forested areas using full-waveform airborne laser scanning. *Journal of Archaeological Science*, 35, 882–893.
- English Heritage (2002). *Environmental Archaeology: A Guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-excavation*. Centre for Archaeology Guidelines 1, Portsmouth.
- Field, N., & Parker Pearson, M. (2003). *Fiskerton, an iron age timber causeway with iron age and roman votive offerings: The 1981 excavations*. Oxford: Oxbow Books.
- Foster, H. (2002). Archives of modern art. *October*, MIT Press, 99, 81–95.
- Gaffney, V. (2008). In the Kingdom of the blind: visualisation and E-Science in archaeology. In M. Greengrass & L. Hughes (Eds.), *The virtual representation of the past* (pp. 125–135). Farnham and Burlington: Ashgate.
- Gearey, B. R., & Chapman, H. P. (2006). In situ preservation, P.P.G.16 and wetland archaeology in the United Kingdom: some present concerns. *Conservation and Management of Archaeological Sites*, 7, 179–182.
- Gregory, D., & Jensen, P. (2006). The importance of analysing waterlogged wooden artefacts and environmental conditions when considering their in situ preservation. *Journal of Wetland Archaeology*, 6, 65–81.
- Grattan, D., Bilz, M., Grant, T., & Logan, J. (2006). Outcome determines treatment: an approach to the treatment of waterlogged wood. *Journal of Wetland Archaeology*, 6, 49–63.
- Grosman, L., Smikt, O., & Smilansky, U. (2008). On the application of 3-D scanning technology for the documentation and typology of lithic artefacts. *Journal of Archaeological Science*, 35, 3101–3110.
- Hatch, M. E. (2012). *Project America: memoirs of faith and hope to win the future*. Matteson, Illinois: Life to Legacy.
- Holden, J., West, L. J., Howard, A. J., Maxfield, E., Panter, I., & Oxley, J. (2006). Hydrological controls on in situ preservation of archaeological deposits. *Earth Science Reviews*, 78, 59–83.
- Jiachang, C., Donglang, C., Jingen, Z., Xia, H., & Shenglong, C. (2009). Shape recovery of collapsed archaeological wood ware with active alkali-urea treatment. *Journal of Archaeological Science*, 36, 434–440.
- Karasik, A., & Smilansky, U. (2008). 3D scanning technology as a standard archaeological tool for pottery analysis: Practice and theory. *Journal of Archaeological Science*, 35, 1148–1168.
- Kenward, H., & Hall, A. (2000). Decay of delicate organic remains in shallow urban deposits: Are we at a watershed? *Antiquity*, 74, 519–525.
- Krawiec, K. (2008). *A watching brief at shardlow quarry: An archaeological and palaeoenvironmental assessment*. Birmingham: Birmingham Archaeology Report 1332.

- Lillie, M. C., & Ellis, S. (Eds.). (2007). *Wetland archaeology and environments: Regional issues, global perspectives*. Oxford: Oxbow Books.
- Lillie, M. C., & Smith, R. (2007). The in situ preservation of archaeological remains: using lysimeters to assess the impacts of saturation and seasonality. *Journal of Archaeological Science*, 34, 1494–1504.
- Lobb, M., Krawiec, K., Howard, A. J., Gearey, B. R., & Chapman, H. P. (2010). A new approach to recording and monitoring wet-preserved archaeological wood using three dimensional laser scanning. *Journal of Archaeological Science*, 37, 2995–2999.
- Modugno, F., Ribechini, E., Calderisi, M., Giachi, G., & Colombini, M. P. (2008). Analysis of lignin from archaeological wood by direct exposure mass spectrometry (DEMS) and PCA evaluation of mass spectral data. *Microchemical Journal*, 88, 186–193.
- Morris, C. A. (2000). *Archaeology of York: Craft, Industry and Everyday Life: Wood and woodworking in Anglo-Scandinavian and Medieval York*. York: Council for British Archaeology Report 17.
- Niven, L., Steele, T. E., Finke, H., Gernat, T., & Hublin, J.- J. (2009). Virtual skeletons: Using a structured light scanner to create a 3D faunal comparative collection. *Journal of Archaeological Science*, 36, 2018–2023.
- O’Sullivan, A. (2005). Medieval fish traps on the Shannon Estuary, Ireland: Interpreting people, place and identity in estuarine landscapes. *Journal of Wetland Archaeology*, 5, 65–78.
- Pryor, F. (2002). *Archaeology and environment of the flag Fen basin*. Swindon: English Heritage.
- Reeves, N. (1999). Ancient Egypt in the Myers Museum. In S. Spur, N. Reeves and S. Quirke (Ed.), *Egyptian art at the Eton College. Selections from the Myers Museum*, 5. New York.
- Rüther, H., Chazan, M., Schroeder, R., Neeser, R., Held, C., Walker, S. J., et al. (2009). Laser scanning for conservation and research of African cultural heritage sites: the case study of Wanderwerk Cave, South Africa. *Journal of Archaeological Science*, 36, 1847–1856.
- Salisbury, C. (1995). An eighth century Mercian bridge over the Trent at Cromwell, Nottinghamshire, England. *Antiquity*, 69, 1015–1018.
- Van de Noort, R., Chapman, H. P., & Cheetham, J. L. (2001). *In situ* preservation as a dynamic process: The example of Sutton common. *Antiquity*, 75, 94–100.
- Sands, R. (1997). *Prehistoric woodworking: the analysis and interpretation of Bronze and Iron Age toolmarks*. Archetype Press: University College London.
- Unger, A., Schniewind, A. P., & Unger, W. (2001). *Conservation of wood artifacts: a handbook*. Berlin: Springer.
- Van de Noort, R., Chapman, H. P., & Collis J. R. (2007). *Sutton common: The excavation of an iron age Marsh-fort*. Council for British Archaeology Research Report 154, York.
- Van de Noort, R., Ellis, S., Taylor, M., & Weir, D. (1995). Preservation of archaeological sites. In R. Van de Noort & S. Ellis (Eds.), *Wetland heritage of holderness: An archaeological survey* (pp. 341–356). Hull: Humber Wetlands Project.
- Van Heeringen, R.M. & Theunissen E. M. (Eds.). (2002). *Dessication of the Archaeological Landscape at Voorne-Putten*. Nederlandse Archeologische Rapporten 25, Amersfoort.
- Watkinson, D., & Neal, V. (1998). *First aid for finds* (3rd ed.). London: UK Institute for Conservation.
- Willems, W. J. H. (1998). *The future of European archaeology*. Oxford Lecture Series 3. Oxford: Oxbow.
- Wright, E. V. (1990). *The Ferriby boats*. London: Routledge.