Abstract  The digitisation of museum collections provides great opportunities for broad communication and access. However, currently the majority of online ‘virtual’ museums present information two-dimensionally. Three-dimensional data capture using laser scanning provides the potential to generate 3D virtual objects that can be used for a much greater interactive experience. This paper presents the results of a JISC-funded project aimed at the generation of a 3D online museum of an internationally important collection of Egyptological artefacts that have not previously been publicly available. The results from the project demonstrate the value of 3D museums, in addition to highlighting some of the future possibilities for interaction with objects and the ways in which such virtual museums can revolutionise access to collections for education and public interest. It also stresses ways in which such collections can benefit scholars in terms of reference collections, object analysis and interpretation. The question of objectivity and authenticity of virtual collections, in comparison with real objects is raised.

INTRODUCTION

Museum, library and archive collections represent, probably, amongst the greatest of cultural resources available to a national economy. Despite this, they are also amongst the least developed. The size and complexity of archives, their fragility, and the technical challenges of making the data available in a
comprehensive manner that has academic integrity rather than simple aesthetic appeal, are amongst the barriers to releasing their potential. This challenge, however, is not one that the UK can afford to sidestep. A recent publication from the UK government noted that

our creative industries are increasingly vital to the UK. Two million people are employed in creative jobs and the sector contributes £60 billion a year – 7.3 per cent – to the British economy. Over the past decade, the creative sector has grown at twice the rate of the economy as a whole and is well placed for continued growth as demand for creative content – particularly in English – grows.¹

It is also apparent that in seeking a resolution to this problem the role of technology is likely to be central. Furthermore, technological innovation has to be supported by creative thinking, and the very process of innovation requires a variety of resources – artistic, creative, technical, scientific, entrepreneurial and managerial.² Additionally, it is important to note the link between the evolution of cultural resources, STEM development and innovation more broadly. Although it is both possible and desirable that many complex problems are broken down into simple steps for analysis and explanation, we do not live in a mechanistic universe. Social and cultural issues are often extremely complex. Solving these issues is as much a challenge for science as it is for the Arts community. Technology linkages between STEM and the Arts may be important to develop novel technological approaches to complex behavioural issues which can be applied elsewhere. Recent studies have also suggested that ‘the creative industries may support innovation in the wider economy by directly supplying artistic and creative inputs to the innovation process, and by embodying transfers of knowledge and new ideas from creative technologies’.³

It is imperative, therefore, that Arts and Humanities engage with this emerging development agenda and particularly consider how Arts disciplines utilise available technologies for their own purposes, as well as their affect on wider social agendas. For instance, the opportunities for academics, creative industries, and cultural institutions to explore the applications of technology within the heritage and creative sector, and increasingly within the context of the exploration and celebration of Britain’s rich mix of diverse, multicultural communities, has the capacity to drive social and economic change and demonstrate that our future economic success relies, in part at least, on a meaningful understanding of our diverse pasts and our capacity to use technology to explore and disseminate this information. In such a context, the imaginative use of technology within an explicitly Arts-driven agenda will begin to provide quantitative answers to some of the issues of impact that are beginning to drive assessment and funding of universities (the graphical approach to such a
The goal is provided in Figure 1. It is apparent, however, that the process to achieve the Arts and Humanities objective of demonstrating their contribution to wealth creation and social wellbeing remains embryonic – and this is where technology has a part to play.

The JISC-funded Eton Myers Collection Virtual Museum Project is, in the light of our rather grandiose introduction, a relatively small contribution to this process. We will, however, suggest that it is an example of what can be achieved and it also shows why digitisation is so important to how we utilise our national cultural resources. Prior to describing the project it is perhaps important that some consideration should be paid to the institution in which the work was carried out. The IBM Visual and Spatial Technology Centre (VISTA) was founded at the University of Birmingham nearly 17 years ago as an archaeological GIS centre, and has developed as one of the UK’s leading Arts and Humanities visualisation and spatial technology providers. VISTA’s existing provision has allowed the development of particular strengths in remote sensing, 3D capture, volumetric and surface modelling, render capacity, agent-based analysis and distributed computing for visualisation and research organisation. VISTA’s recent projects have ranged from exploration of the vast inundated landscapes hidden beneath the North Sea, modelling of heritage structures in world heritage sites in Cyrene, Diocletian’s palace and Ironbridge, agent-based
models of the logistics of the march to Manzikert (1071) and java-based multimedia exploratory tools to explore and interpret the Stonehenge landscape. Although clearly oriented towards the development of technology within an archaeological context, VISTA has increasingly acted as a conduit for Arts/STEM collaboration and has frequently sought to work within the context of the museum, library and archive community but also to interface with the wider context of the West Midlands regional economy. The concept of the virtual museum is therefore of considerable interest to the research group at Birmingham.

3D LASER SCANNING AND HERITAGE

The introduction of laser scanning technologies within the Arts and Humanities is having a dramatic impact within a range of applications at a range of resolutions. At the broadest level, airborne laser scanning (LIDAR – Light Detection and Ranging) is providing opportunities to generate highly accurate, high resolution models of entire landscapes, with the ability to map topography through dense tree cover. At a terrestrial level, laser scanning is providing the opportunity to record built heritage at high accuracy and dense resolution, as demonstrated on a number of sites, and in combination with other technologies.

The application of 3D scanning to objects has to date been focused on the interpretation of artefacts, and the objective documentation of metric data, such as physical dimensions, although these data can be used to derive other information. For example, a study of Palaeolithic axes used the results from scanning to determine objective and systematic measurements that could be used in documentation and interpretation. 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.

More recently, the technique of object laser scanning was used to assess conservation conditions of wet-preserved archaeological wood. In this study, objects were scanned on the day of lifting from site, and then scanned at successive periods with each item stored in different conditions. A process of comparison between the scans from different times facilitated the accurate volumetric measurement of change.

These examples are similar in many ways. In each case, scanning was undertaken to provide data that could be analysed to reach interpreted conclusions. This is not to say, however, that the digital objects provide an undisputed product. It should be clear that the metrical description of an object is not itself an act of interpretation. However, each example also provided an archive of data that could be re-used in the future, both in terms of the documented interpretations, but more importantly the scan data itself. The use of three-dimensional recording for the remote analysis of objects, either in themselves, or
The Eton Myers collection as reference collections has been further demonstrated by Niven et al.\textsuperscript{14} In their study, laser scanning was used to generate a virtual archive of faunal remains. In this case, the aim was to generate a comparative collection against which future study could be undertaken.

The development of three-dimensional laser scanning of objects, therefore, has been focused on a range of specific outputs, although the studies share commonality in the generation of virtual archives that may be used in the future either in relation to further virtual archives, or in comparison with physical objects. In this way, the archives that are generated provide valuable information that can be built upon, made available and analysed in the future, whilst providing a valuable element of preservation by record. Thus, it seems extremely appropriate that such a technology should be used as the basis of a virtual museum.

The Eton Myers Collection of ancient Egyptian art was bequeathed to Eton College, UK, at the end of the 19th century by Major William Joseph Myers (1858–1899), a former Eton pupil (1871–1875). As an Aide-de-Camp to the General commanding in Cairo, Myers first went to Egypt in 1882 and became interested in ancient Egyptian and Islamic art, soon distinguishing himself as one of the most important private collectors in Egypt until his last visit in 1896. Myers became acquainted with some of the leading Egyptologists of his time, among them being Émile Brugsch, assistant curator of the Boulaq Museum (the Cairo Museum today). Myers bequeathed approximately 1300 objects to Eton College, although the collection was since supplemented by objects from el-Amrah, excavated by the Egypt Exploration Fund (1898–1899), 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,\textsuperscript{15} 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.

Today, the Eton Myers collection can be described as the finest of its kind with the least public attention. Although curated by Eton College, it has never been fully researched or documented, with the only publication currently accessible listing just 100 pieces of the approximately 3000 or more items.\textsuperscript{16} Despite this lack of study, the ‘masterpieces’ of the collection are well known, having travelled the world since 1999, visiting Leiden, Hildesheim, Madrid, Bordeaux and Tokyo. In New York, where some items were displayed in 2000/2001, the exhibition held at the Metropolitan is still ‘remembered as one of the most successful small exhibitions to have been staged in recent years’.\textsuperscript{17}
RATIONALE FOR THE DIGITISATION OF THE COLLECTION

The demonstrable international significance of the collection for scholarly study has been tempered by lack of access. The restricted access to the collection is augmented by the lack of a complete catalogue or publication about the objects. Furthermore, the nature of the items, comprising three-dimensional objects of art, means that study cannot be facilitated through two-dimensional photography.

In 2008, these issues were identified and, in collaboration between Eton College and the University of Birmingham, a programme of three-dimensional digitisation of the objects was undertaken, funded by the Joint Information Systems Committee (JISC). The primary aim of the project was to address issues of access by making the collection accessible to the broadest possible demographic via the Internet as a virtual collection. This demographic included 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 metrical analysis.

METHODS

In order to address the needs of the project, and to assist in interpretation by period specialists, a three-dimensional approach was used for digitisation. This is because both the objects and much of the information that they can provide are three-dimensional. For example, many of the items have 3D surface detail such as etched hieroglyphic text which could be explored and examined in detail through surface analyses and adjustment in lighting sources. Furthermore, in some cases, such detail including text continues around the object—it is not possible to read it without physically (or virtually) turning the object (Figure 2).

Hence, the methodology for the creation of the Eton Myers Collection Virtual Museum was designed around 3D surface capture, and extended to data processing and the production of a 3D model of each item, thus forming the Virtual Museum. The resulting models were then decimated to a size appropriate for web delivery, and accompanied by catalogue text provided by specialists in ancient Egyptian objects. Hence the objective of the methodology was to generate a high-resolution Virtual Museum curated by the University of Birmingham that could be accessed for scholarly purposes, with a lower resolution, three-dimensional frontend Online Museum for universal access.

To generate high resolution colour 3D digital objects, an approach using non-contact 3D laser scanning was adopted. The principal scanner used throughout the project was a tripod mounted Minolta Non-Contact 3D Digitiser VIVID-910. This instrument has a relatively short range (most accurate at between 0.6m and 1.2m) but records positional information including colour rapidly and at a high
accuracy (±0.22mm \((x)\), ±0.16mm \((y)\) and ±0.10mm \((z)\)). In addition to the Minolta VIVID-910, a selection of the objects was scanned using a NextEngine 3D HD Scanner (2020i) at an accuracy of ±0.13mm to ±0.38mm at a target surface resolution of 400DPI to 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.

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). For larger objects the number of necessary scans was considerable. The scans for each object were registered together and stored as raw ‘point clouds’. They were then meshed and cleaned using Geomagic software to provide continuous surfaces, and were stored again as meshed objects. 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 500MB and 3GB.

To form the online frontend Online Museum, the large 3D datasets needed to be decimated to a smaller size and output in 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 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 10MB to 25MB) 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.

RESULTS

The resulting high-resolution Virtual Museum and Internet-based Online Museum provide a multi-resolution 3D virtual resource for anyone who is able to access the Internet. The associated catalogue entries provide information about each item whilst the models provide interactivity and visualisation, and allow for the further analysis of the objects.

The scanning process itself has proven a valuable tool, particularly in the transcription of hieroglyphic and hieratic signs on a number of items in the collection. For objects where there was an issue with degradation of the texture, or distortion due to variation in colour, it was possible following scanning to provide a 'solid' geometric 3D replica of the item. The resulting model subsequently provides a clear representation of many otherwise illegible inscriptions (Figure 3). This process has also proven to be useful in the identification of tooling marks on some of the wooden artefacts. Furthermore, it was noted that variations in scanning hardware provided quite varying responses to different material surfaces. For example, the more reflective object surfaces (such as alabaster and faience) were best captured with the NextEngine device rather than the Minolta, as it reduced issues with laser surface penetration and range artefacts.

The creation of a 3D database of objects such as the Eton Myers Virtual Museum has not only enhanced research through access to the items, but
The Eton Myers collection

[Image 144x577 to 444x688]

Figure 3. Surface analyses used to highlight inscriptions on one of the objects.

has also facilitated exploration into the application of other developing technologies – especially those that improve the ability of a visitor to interact with items. Experiments with haptic interfaces in collaboration with the company SenseGraphics have demonstrated other ways of engaging with virtual museum collections by providing tactile responses to a user when interacting with synthetic models by applying simulated forces to generate the feel of touching the genuine object. Additionally, the archived databases of scanned objects provide the opportunity for rapid prototyping of objects through three-dimensional printing. From the digital object it becomes possible to replicate to allow users to touch, hold and even own highly accurate copies of valuable or fragile items which would not have been possible previously (Figure 4).

DISCUSSION – 3D MUSEUMS AND POTENTIAL

The Eton Myers Virtual Museum Project was aimed at making an important collection of objects widely available for teaching, scholarly study and general interest by both curating an accessible collection of high-resolution virtual objects and presenting the collection over the Internet. As a Virtual Museum, the aim was also to generate a simulation of the items so that they could be interacted with in similar ways to physical objects. What is lost in terms of physicality is arguably gained by lack of fragility (the objects can be virtually handled without risk of damage) and increased ways of viewing the items (such as without texturing, with refined lighting and the ability to zoom in). The value of the facility to pick up and move the items to explore their three-dimensionality is illustrated by the items that display hieroglyphic writing circling the objects which thus require movement to read them. In addition to these principal aims, the Eton Myers Virtual Museum Project has also preserved the items as virtual objects.
Beyond the original scope of the project, the virtual models provide far greater potential for future use. Experiments with alternative ways of interacting with the objects have demonstrated a range of future opportunities. The application of haptic technologies has demonstrated how the objects can be touched, felt and moved. Due to their fragility, many of the objects within the collection could not normally be touched, but with the application of haptic technologies to the virtual models, handling becomes possible. Furthermore, the models provide the opportunity for re-creation through rapid prototyping or 3D printing. Accurate
The Eton Myers collection replicas can be produced infinite times directly from the virtual models without any need to access the original items. The high-resolution models will be curated for the future enabling changes to the models available on the Internet or through other interactive approaches can be made without altering the models.

The successes of the Eton Myers Virtual Museum Project will be measured through its future use and growth as more items become digitised and added to the collection. However, the virtual objects raise issues regarding the nature of museums more fundamentally. Previously, virtual museums hosted on the Internet consist of 2D and occasionally 3D representations of objects held in physical museums. The Internet resource is a decimated representation or front end to the actual collection. The Eton Myers Virtual Museum is different. Here the Internet resource (Online Museum) serves a similar function, consisting of decimated representations, but in this case they are representations of high-resolution virtual objects (Virtual Museum). The original objects are owned by Eton College, whereas the Virtual Museum’s high-resolution objects are curated by the University of Birmingham. In this sense, the Internet site provides a front end to a virtual collection – the first of its type.

If we begin to consider this interpretation of a virtual museum, then we can begin to re-consider usage. From the perspectives of study, education and learning, the virtual objects provide an extremely valuable resource which in many ways provides greater potential than the original objects. However, from the perspective of museum visitors, the items are virtual replicas. They are not the real items. The greatly increased accessibility reduces the concept of rarity. Ease of access limits the sense of pilgrimage. The virtual objects are not the rare or valuable objects that inspire awe. Arguably this is a small price compared with complete inaccessibility to a collection. However, this issue of authenticity is something that the creators of virtual museums must begin to embrace and respond to. With heritage tourism contributing £12.4 billion to the economy of the UK every year, the imperative for academics to engage with technologies that disseminate knowledge is significant and, it should be noted, that such engagement includes the requirement to ensure that digital data and its interpretation is accurate and accessible to the wider public18.

CONCLUSIONS

The Eton Myers Collection Virtual Museum Project has highlighted the ways in which digital technologies can enhance museum provision. More importantly, however, the project has highlighted the potential ways in which such technological approaches and developments can address more fundamental issues. The world of online museums is already here. The benefits are great for scholarly use, for broader pedagogic requirements but also for our creative industries. The availability of innovative technology, and the willingness of
research councils to support such applications, provides this important sector with access to materials never previously available. In doing so we may be able to realise a step change in the relationship between Arts, STEM subjects and the broader creative sectors of the economy. If this is achieved it is possible that we may, for the first time, realise the immense social and economic worth of our nation’s heritage.

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END NOTES

1 DCMS, Creative Britain. (Department of Culture, Media and Sport, 2008).
2 DIUS, Innovation Nation (Department of Innovation, Universities and Skills, 2008).
4 www.vista.bham.ac.uk
The Eton Myers collection


