Practical experience of 3D image modelling of cultural objects at the V&A Museum

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Abstract:
This paper describes the method of making 3D image models oif cultural objects in the V&A Museum. The work was undertaken by the Photo Studio in the museum and a relationsghip is made between the working methods for 2D image making and how this differs for 3D. The reasons for 3D compared to other developments in imaging are made and a consideration is made for the use by other professional staff in the museum. An estimation on the financial cost for the development of a 3D digitisation programme is included.

Introduction

This paper describes a trial undertaken in the V&A Museum Photographic Studio as part of the EU FP7 project 3D-COFORM. (The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007 2013) under grant agreement n° 231809.)

The 3D-COFORM consortium has one over-riding aim: "to establish 3D documentation as an affordable, practical and effective mechanism for long-term documentation of tangible cultural heritage". The purpose of the trial was to create a workflow for 3D imaging suitable for a museum photographic studio, and to measure its cost effectiveness and suitability for the range of objectives held by a national museum.

Methodology

For the purpose of this exercise undertaken at the V&A Museum, the concept of a 3D imaging trial contains several elements. Each of these are separate but necessary to one another to make the idea of 3D modelling of cultural objects both viable and potentially necessary to the Cultural Heritage organisation.

Ideally scholars require images of CH objects for a reason. This may be for publication, teaching, peer to peer comparison, conservation related activities as well as making the collection better known to the public. Just as for decades the art historian was satisfied with black and white images and indeed had difficulty in both trusting and using colour images when they were first made available to them, then 3D imaging faces similar questions for the scholar. They currently do not yet fully understand it's potential. One of the purposes of our trial was as an educational exercise. Comparing results of different objects will enable them to better judge the technological potential and then predict when it will be useful and hopefully essential for their work.

Within CH institutions it is the subjective responses which are often the more interesting. There are many parallels to the 2D world. Colour is the most vivid example. The question is often, "is the colour in the object the same as the image"? There are many objective ways to isolate colour matching from using referenced light sources to assigning correct colour profiles on calibrated monitors. However it is the direct comparisons that the scholar will rely upon.

Success will depend on both the viewer of the object, their individual needs and the medium of delivery of the image. Different audiences will have different responses and judgments for success. The museum visitor may just relish the opportunity to see an image in the round, to have an appearance of form and to just see the back of an object; something often denied them in the museum display case. The scholar may be more discriminating and need to be assured of measurements and surface detail. The conservator may want to compare and contrast objects pre and post restoration. All of these different uses are equally valid.

The V&A Photographic Studio is well appointed for imaging in a CH institution, its staff are experienced in all forms of object photography and well practised work-flows have been developed for the successful completion of digitisation projects. The Photographic Studio is well equipped with lighting and general photographic accessories so background equipment is substantial. This may not always be available to a smaller museum situation. V&A services for art handling and cataloguing were available from it's own resources.

The trial has been undertaken by Carlos Jimenez and Una Knox of the V&A Photographic Studio. They are both photographers by training but have extensive skills in a range of media software. The expertise they bring to the trial is an understanding of the care and consideration necessary with cultural objects, knowledge of lighting objects for reproduction and the skills to use well established and new computer graphic software. They also understand the working arrangements within the museum in the cultural heritage sector, a factor which can influence how work can proceed on an object.

The majority of the scans in the current trial have been undertaken on the Breuckmann Supper Scan HE device. This camera has interchangeable lenses of 180mm 300mm and 800mm focal lengths.

Fig. 1: Breuckmann SMART SCAN HE

Fig.2: A typical setup for V&A scanning

Training

After receipt of the Smart Scan, Bernd Breukman visited the V&A Photographic Studio to train Carlos Jimenez and Una Knox in use of the scanner.

The training took place over two days within the main Photographic Studio space at South Kensington and a couple of objects were scanned during training exercise.

The introductory training that Carlos Jimenez and Una Knox of the V&A Photographic Studio received at the V&A London was sufficient to begin creating 3D models with the Breuckmann Scanner. With basic technical knowledge of the scanner and the accompanying software they were able to understand the working process and start to build a portfolio of new 3D models.

It was soon realised that while the speed at which acquiring scans and blending meshes into models steadily improved, using the same parameters in the software and the same adjustments for each acquisition was not suitable for different materials, different surfaces and different objects. The software has many tools which can adjust the parameters effecting different aspects of the

acquisition and post-processing of the mesh. In order to gain more experience in the use of these different parameters Carlos and Una undertook further training at Breuckmann Headquarters in Germany.

Within the V&A museum collection the variety of materials is vast, with each object often possessing a unique range of textures. As a result of this diversity, it would be difficult to pre-visualise questions about the best scanning procedure ahead of the physical scanning of objects. The second training session allowed the right questions to be asked as by then the photographers had become familiar with textures previously captured. Knowledge had been gained in what was required in terms of accuracy for the 3D models. They were also able to draw on a substantial understanding of the way the combination of scanner and its software react to materials based on the experience of Breuckmann staff.

Working procedure

The first approach towards the scanning process is very similar to that in any form of photography process in a museum environment. There is the need to locate the object, move it, choose the working environment, select the appropriate lighting, and start acquiring images to produce the desired image. There are however also software parameters and manual operations that relate only to the 3D output properties. But mainly the approach we adopted towards 3D was through our understanding and experience of 2D photography.

As in any imaging technique the software and its behaviour are as important as to how the object relates to the environment and lighting. These two sides of the process; physical and virtual shaped the behaviour much more than in 2D photography. The result in 2D photography depends on different images that represent an object with a specific purpose; it's appearance, it's texture properties, it's dramatic features etc. The result will be a static image frozen in time and space, non-moveable therefore non-receptive to light changes and dynamism. Meanwhile on the 3D image there is a need to obtain a model with texture as neutral as possible over all the parts of the object. These parts will relate to one another in a much wider sense than with the 2D photographic approach. The object needs to be broken into pieces so the neutral aspect of all single aspects will produce a coherent image. The image should react to light, movement and be humanly recognisable as natural as the real object will be in real life.

The approach to developing this technique has evolved through experience, striving to fail was the approach to understanding how the scanning process works in the best way. We spent a lot of time on handling objects at the beginning of our tests. As there is a physical element in the relationship between the way that light, reflections, and quality of region are acquired, there is a procedure that needs to be understood before we get the maximum out of this. The light has definite properties of direction, brightness and exposure that needs to be taken into account. This specific nature of the scanning process has a direct relation with the properties of the object; shape, material and texture. All those parameters mean that the handling of the object and the handling of the scanner have a relationship that affects the success of the scanning process.

Therefore our experience in scanning with Breuckmann's Smart Scan improved not only on the technical side, but also in our physical approach to undertaking the exercise. Selecting the lighting, moving the object in a certain manner particular to that object, changing software parameters and combining different lens resolutions, is part of our development of this scanning workflow.

Lighting the scene for scanning.

Due to the nature of the scanning technique used, with the need to make a large number of scans around the object, we developed a method of lighting the scene to reduce as much as possible the change of colour and shadow created on the object. Normal practice was to mount the object onto a small turntable and rotate the object between scans with the scanner and lights kept in a fixed position. The turntable was itself set within a rigid fibreglass cove background painted a neutral white colour. This was illuminated with flash soft boxes. In this way the lighting on the subject was

even, 'wrapped around' the object and reduced the shadows considerably. The intention was to make the lighting on the object exactly the same for each view of rotated object.

Each object then in our opinion can exhibit several features which will affect the efficiency of the scan:

Texture (roughness)
Reflectance /diffusion (how shiny and how the light is distribute)
Occlusion
Rigidity
Transparency/translucency
Noisiness (a function of texture but a characteristic in its own way)
Size (physical dimension of the object)
Colour

Post Production

Post-production is a skill which only comes with experience and time for practice. Initially the post-production was undertaken in a simplistic fashion; only changing compression, triangulation, and changing from preview to full-resolution mode.

Experience gave us more access to the other parameters, both in Optocat and MeshLab, which improved the modelling effect. These are difficult to learn, but the more experience the better. However with experience comes the realisation that the exercise becomes more complex. More control is needed, and we found that you tend to delete more information from meshes, so you become more selective in the parts of acquired data used for the final model.

When you change the parameters for more detail, or resolution, the errors can become greater between the meshes and the colour etc, and these enhance any faults created during acquisition, so the post-production time becomes longer and more involved. So if you are after high accuracy then the post-production takes much longer. This would of course become a consideration when you make be re-processing data for different uses. Web delivery may mean that less accurate post-processing could be acceptable when high resolution post-processing would require far more diligence.

Discussion was taken as to the value of having the post-processing done by the same person who undertook the acquisition or by a different individual. At the V&A we have mainly kept to one individual for the whole of the modelling cycle. If the operation is split between acquisition and post-production then the data gathering during acquisition must be more rigorous and complete. By this we mean that as much information about the objects composition; its texture, colour, occlusions etc, must be made as well as 2D images as a guide for the post-production individual. Also some mesh layers have good and bad parts. If one operator knows this in advance then complex meshing is an easier task. An understanding of which scans are to be used for difficult occluded areas is useful as these will be used in a different way to those made for the general surface.

In a small scanning campaign then one operator is probably the best approach. In a big campaign then multiple operators may be better. However changing the tasks in a shift system may be refreshing, and certainly when learning the practice an all round understanding of the whole process is important.

Operating costs

The V&A Photographic Studio is a wholly funded department of the V&A Museum. It operates with full-time employed staff in purpose built studios within the museum buildings. Hence the cost of effort for 3D scanning comprises of the following elements:

- Staff cost
- Capital equipment cost and depreciation

To run a full-time scanning campaign we would consider that two photographers necessary to run this effectively.

Equipment cost based on the Breuckmann scanner is approximately ¤80k. This is assumed to depreciate to zero over four years. Other institutions may or may not already have support equipment such as lights, backgrounds in place. If not these would cost in the range o ¤17,500.

Hence start-up cost would be a total of staff, at mid-point on the scale, and equipment would be approximately ¤150,000. Second and subsequent year costs would be ¤53,000.

If a normal working year is considered to be 250 days per year, then it would be reasonable to expect to make at least around 150 models per year. With experience and improvements in workflow this could be expected to increase to maybe 250 models per year. This does of course depend on the object type. On average then, over a four year period, could be expected to cost ¤300 per model.

Conclusions

Undertaking this trial presents the V&A Photographic Studio with the development of a workable method for creating a new multi-media product for the Museum. The experience gained from undertaking training and understanding the range of cultural heritage objects that can be scanned successfully has meant that a realistic 3D digitisation exercise can now be undertaken. This gives us encouragement to be able to offer this as a museum service. The presentation of 3D models to staff in the museum has created interest in the medium and has allowed them to consider how it can assist them in their work or be able to present the collection to the visitor in new interesting ways.

Workflow and development of a production environment

During the course of this trial the V&A has realised that there are both differences and similarities between 2D and 3D workflow. The similarities though can form the basis of an effective production cycle. With this in mind the V&A Photographic Studio has taken advantage of its experience of photographing the cultural object in a public service museum environment and applied it to 3D. Though our public service element is particular to a well-resourced National Museum, the principles can be applied to anywhere there exists a competent professionally trained photographic service. The elements of workflow which are comparable are;

- Initial response to an imaging request
- Assessment of the object
- Access and movement
- Imaging setup

All of these elements, though they may differ from CH institution to CH institution, will be the same regardless of the imaging task. Indeed they are largely the same for any activity taking place on the CH object.

For 3D imaging however the differences can be shown as;

- Decision on technological approach
- Capture process
- Storage

The issue of 'fit for purpose' scanning is one which is still relevant for 3D, however we have largely followed our general 2D principle of 'scan once, use many times'. In our 2D workflow we make images that will be reproduced at least as A3 at 300 ppi. In this way we cater for almost every use that the Museum may need for its images. It is with this in mind that we scanned objects as efficiently as possible. So this dictated our technological approach. This was determined early on in our trial and continued for its whole period.

It is these areas where training in the 3D medium is needed and where extra attention to IT infrastructure particularly for storage needs to be assessed before a campaign is started. At the V&A the time needed to become fully comfortable with the technological approach has taken at least six months. Though acquisition took place well before this, it took this period of time to become fully comfortable with the way that CH objects are recorded in 3D and how the many parametric features of 3D software can effect the visualisation of the final model. The V&A were fortunate to receive training from the supplier of the structured light scanning equipment used, but experience and observance of effects of actually doing the work is necessary.

It was the intention of the V&A to gather as much experience as possible, represented by the wide variety of objects housed in the museum. There are still many different objects which will present new challenges, for example we have not yet scanned either furniture or dressed mannequins, but the range scanned has indicated which objects can be considered, difficult, challenging or impossible.

Practical issues

Scanning in 3D is lengthier process than 2D imaging. This has an effect on the use of workshop spaces. To fully complete a task requires that space is occupied for at least 24 or 48 hours. For 2D the turn-round time for a studio can be within 1 or 2 hours. This has an effect on the efficient use of space in the workspace suite. For the manager of 2D production the cycle is rapid, for the 3D manager longer. Hence to combine the two disciplines can be difficult. With this is mind to undertake a substantial 3D digitisation campaign would require its own dedicated workspace.
Imaging in 3D in terms of the scene is substantially different to that in 2D. In 2D imaging the background in the image is important to the perception of that object represented in the scene. A poorly composed background can make a image of a CH object itself look poor. To achieve a well composed background requires skill in lighting, and space to organise the lighting setup outside of the scene. In 3D modelling the objective is just to acquire an image of the object and to leave the construction of a background visualisation to post-production. This means that less care can be taken with the background and lighting rig during the acquisition phase. If wires or lighting stands trail into the scene or the background is uneven and poorly lit it is largely irrelevant. During the trial we often had to work in museum stores of galleries. These spaces are less versatile than Photographic Studio spaces, but due to the nature of the acquisition did not compromise the imaging.

Preservation issues

It was a surprising consequence of undertaking 3D scanning to realise that there is a fundamental difference to 2D imaging. The 3D acquisition process is a multi-stepped task creating no single 3D file, because unlike 2D you are working in the round, rather than on a single face of an object. 3D acquisition comprises of making multiple exposures and compositing these into a single whole. The multiplicity of files made in this process is considerable and varies with the different proprietary devices used. All of them however make large directories of folders and sub-folders of meshes, images and other production files. We have measured that there can be a ratio of 27:1 for 3D production where of course for 2D imaging it is 1:1. This raises the issue for digital preservation as to whether you retain all of this production data or just the final 3D model. Even with our limited experience we have realised that you can re-process the production data to make refined models, and that there can be other operators who can take your data and made different iterations of the object.

For the IT department this is a considerable issue to take into account. When a 30Mb 3D model is made from 4.7 Gb of data, then in a large scanning campaign the numbers soon build up into terabytes of storage. This has the consequence for digital preservation of format redundancy and migration and substantial back-ups. As much 3D scanning is undertaken on proprietary devices, file formats vary and sometimes only work on single software platforms. So it may also be necessary to keep software versions, which of course have the consequence of changing operating system platforms.