Galloway Glens 'Can You Dig It' Community

Archaeology project – Technical notes.

3D Models from Photographs - Training Workshop Note

What are 3D models?

3D models are used in movies, animations and video games but are also used in many scientific fields and increasingly in recording built-heritage and archaeological sites and artefacts. 3D modelling is the process of creating a 3D representation or visualization of any surface or object by manipulating polygons, edges and vertices in a simulated 3D space. A physical version of this would be creating a papier mache model with a ridged frame of wire, over which paper pulp and glue would be spread to create a shape which once dried out would then be painted. This is essentially what happens virtually in your computer while making a 3D model.

Quick overview on Digital Documentation

There are various forms of digital documentation which can be for the recording of heritage objects or structures such as LIDAR (light detection and ranging), Laser Scanning, RTI (reflectance transformation imaging) and structure from motion (SFM) photogrammetry. All of these can produce 3D models or visualisations of varying scales and complexity.

Lots of heritage organisations from local community groups through to the National Museum Scotland are beginning to utilise this new technology. Some of these technologies, such as laser scanning, can involve expensive equipment, software and training at the start. Luckily structure from motion photogrammetry (often called photo scanning) is a bit more accessible and more importantly, it's cheap.

Though you can spend a lot of money on creating 3D models through photogrammetry it is possible to use something as simple as the camera on your mobile, free or open source software found online and a modern pc or laptop (though without a good graphics card in it, creating a 3D model could take a while) and still get some pretty decent results.

Some examples of the different larger projects that have made use of digital documentation are shown below:

- **Forth Bridges** 3D Project

- 3D Digital Documentation of **Edinburgh Castle Fore Well**

- St Andrews University's 3D reconstructions of parts of **Edinburgh**

- Glasgow School of Art's 2017 Degree Show (Shona Noble) visualisation (with sound) of **Fingal's Cave** on the Isle of Staffa

For more information on Digital Documentation you can download and read Historic Environment Scotland's **short guide.**

How do you create 3D models?

3D models can be created either manually (like papier mache models or sculpting with clay) using specialized 3D production software such as Blender or Maya that let users create and manipulate polygonal surfaces, or by scanning real-world objects through photogrammetry or laser scanning software, such as 3DF Zephyr, Agisoft Metashape or Meshroom, into a set of data points that can be used to represent the object digitally.

With photogrammetry, the 3D model is created by first taking a series of overlapping photographs from as many different angles as possible of say, a tree stump, which you will then upload to your computer and process using the photogrammetry software of your choice. Depending on the software you use it is possible to edit your photos and set how detailed you want the resultant 3D model to be.

General Rules for Data Capture for Photogrammetry are:

- Do your best to keep the object or structure centred while framing your photos

- With photogrammetry outdoors, it is best to avoid direct light sources (i.e. very sunny days) that may cast shadows and hide parts of the object or structure's surface areas. With photogrammetry inside, you may have to add diffuse light sources, use a plain backdrop and possibly use a turntable for smaller portable objects in order to get good results

- Try to avoid high ISO values on your camera as it can create a noisy background which will confuse photogrammetry software packages.

An ISO value of 200-600 is a good rule of thumb, although usually the lower the better

- Use a high aperture value (F/8 – F/16) for your camera as this will help with obtaining a deep depth of field for your photos

- Keep your shutter speed at a higher value: 1/125 or more

- Try not to take blurry photos. Using better quality cameras, having the right type of light or using a tripod can help reduce this risk

- **One of the most important rules is that you make sure your photos have at least a 60% overlap** (though 70-80% would be better). Try to shoot as many photos you can. If you think you're finished, take some more!

- For an object like a statue or gravestone, you will need to circle it, taking photographs at 10° intervals, which will mean 36 photos for each circle. You should repeat this with the camera at different height levels (for instance crouching or standing) and at different distances from the object (sometimes getting very close if there are details on the object such as carvings on a gravestone). The number of photos you can use within the software may be hampered by the type of software you're using (e.g. 3DF Zephyr Free only allows 50 photos)

- You should also keep in mind when taking your photographs UK law with regards to privacy (near privately owned property) and/or protection of children (near schools or nurseries). It's also a good idea to seek permission before you start to snap away.

Listed below are the different types of software which can be used for photogrammetry and 3D modelling once you've acquired your photogrammetry data. There are also others available.

Free Software:

- 3DF Zephyr Free - Has a limit of 50 photos per model but other than that, perfect for starting out.

- Meshroom - Very new software which is very good but you need to use other software to upload to Sketchfab. Hopefully new versions will allow this in the future.

- 3D Regard - Good, but slow, free software, though needs to be edited in other software.

- Visual SFM - Good, but slow, free software though needs to be edited in other software.

Paid Software:

- 3DF Zephyr (Lite & Pro) - Fast software though the Lite version is limited to 500 photos (permanent licence £127-£3,300)

- Agisoft MetaShape - Fast software though the standard version has limited functionality (permanent licence £135-£2,634)

- Reality Capture - One of the fastest softwares out there with plenty of functionality (£85 for 3 months or £3,420-£13,000 for a permanent licence)

- Pix4Dmodel - Good software with plenty of functionality. Cloud processing allows people with older computers to create 3D models online (£36 a month & free trial)

- PhotoModeler - Good software with plenty of functionality (£37 a month, £750 for a permanent licence & free trial)

- AutoDesk ReCap - Fast software with plenty of functionality (£42 a month & free trial)

3D modelling software (for editing & uploading):

- [Blender](#) - Allows the creation of 3D models from scratch, editing of 3D models, upload to SketchFab and many other uses (free)

- [Maya](#) - Allows the creation of 3D models from scratch, editing of 3D models, upload to SketchFab and many other uses (£216 a month & free trial)

- [Meshlab](#) - Allows the editing of 3D models and upload to SketchFab. Difficult interface (free)

- [3DS Max](#) - Similar software & pricing as Maya.

What Equipment do you need to do Photogrammetry?

As mentioned above, it is possible to create 3D models with as much or as little equipment as is available or affordable. It is easy to create a basic model say of a gravestone or small statue using the camera on your smartphone or a point and click camera. Many phones and basic cameras allow you to change ISO and/or shutter speed so it is possible to get good results. It is also possible to get a good result using the automatic settings on your phone or camera without having to go into the settings of your device. To get better results, using a DSLR camera is your best option, particularly where the lighting conditions are trickier such as a dimly lit interior.

To stop your phone or camera from shaking it is a good idea to set it on a tripod which will reduce the chance of blurry photos. It is also possible to mount your camera on an extendable pole (or even a selfie stick for your phone) which is useful when the object is larger, for instance a building or tall statue. Care should be taken with these as they could be dropped in windy conditions, and you should check there are no overhead services.

Below is a list of what you need for carrying out photogrammetry for a simple object outdoors:

- Smartphone or point and click camera with over 5 megapixels (though 8 megapixels would be best)

- Free or open source photogrammetry software

- A computer with decent specs (at least 8GB RAM and a dedicated graphics card)

To get better results the following would come in handy depending on what you're trying to achieve:

- DSLR or Bridge camera

- Paid unlimited photogrammetry software

- Portable LED lighting

- Tripod, camera pole, selfie stick

- Portable camera tent and neutral backdrop

- Turntable (for smaller object photogrammetry)

Where can you display your 3D Models?

Though there are a number of online websites where 3D models can be uploaded and displayed, by far and away the best is **Sketchfab**. Sketchfab is like the YouTube for 3D models and though there are yearly and monthly paid plans to use it, there is an unlimited free plan which meets the needs of most users. Sketchfab allows the editing of 3D models and the use of text captions, animation and sound so that it's possible to present a professional looking 3D model.

Many of the photogrammetry and 3D modelling software packages allow you to create basic animations with your 3D models which can be uploaded to **YouTube** or other similar websites. This is useful as sometimes more complicated models are hard to view on some computers, phones or tablets. It is also possible to link or embed 3D models and videos of them onto a website, blog post or social media.

Below are some suggested links to collections of 3D models by:

- Thomas Flynn on **Monuments & Sites** and on **Museums, Galleries & Exhibitions**;

- the National Museum of Scotland on **Scottish History and Archaeology**; and

- Dr Hugo Anderson-Whymark on **Skara Brae : Structures**.

Case Study 1 – Cadder Parish Church, East Dunbartonshire

My first attempt at photogrammetry was at Cadder Parish Church, East Dunbartonshire. The work was carried out as part of a small project which involved researching some of the history of the church and the village of Cadder. We brought in photogrammetry to help record architectural elements of the church, gravestones and other structures within the graveyard, such as a mortsafe and watch house used to stop grave robbing in the early 19th century.

The resulting **article** shows the results that can be achieved using just a smartphone and free software to produce the **model collection**, though a higher spec computer was still needed to process the data. If high spec computers are not available then photogrammetry software such as

Pix4Dmodel could be used, as it can be processed online via cloud processing meaning any computer can be used (though it has a monthly cost to it).

Case Study 2 – Culzean Castle, South Ayrshire

Rathmell Archaeology's first use of photogrammetry was during excavations to look for the early 17th century walled garden within the Fountain Court of Culzean Castle. The excavation identified the SSW corner of the wall and the National Trust for Scotland asked for photogrammetry to be carried out for the excavated area.

Aerial photo of the excavations at Fountain Court during the excavations.

The on-site data was captured using a DSLR Camera after the excavation had just finished up. The photos were taken by circling the excavated area at a crouched and standing level with all of the photographs overlapping each other by at least 60%. The **model** was created with 3DF Zephyr Lite using over 200 of the photographs which were taken on site. The editing of

photographs and processing of the images took 3-4 hours (using a PC with an NVidia Graphics Card).

Screen Capture of the finished 3D Model

Case Study 3 – 18th century Well at Levengrove Park, Dumbarton

One of Rathmell Archaeology's most recent uses of photogrammetry and 3D modelling was during the excavation of an 18th century well which had been exposed at Levengrove Park, Dumbarton after the storms of September 2018 blew over a tree (over a hundred years old) which had grown over it. The excavation involved the usual archaeological techniques such as shovelling and trowelling but also involved the clearing out of debris and water from the bottom of the well. The latter work was luckily carried out by West Dunbartonshire Council.

View of the Levengrove well after excavation

The on-site data was captured using a DSLR Camera after the excavation had just finished up. The photos were taken by circling the excavated area at a crouched and standing level. A series of higher angled photos were obtained using a 2-3m pole which the DSLR was mounted on. The camera mounted pole was also lowered carefully into the bottom of the well to capture data there. All of the photographs taken overlapped each other by at least 60% and a number of close up shots were also taken to try and get more detail of the stonework used in the well's construction. The **model** was created with 3DF Zephyr Lite using over 300 of the photographs which were taken on site. The editing of photographs and processing of the images took 4-5 hours (using a PC with an NVidia Graphics Card).

Using Camera mounted on pole to record the bottom of the well with mobile for DSLR remote.

Another 3D model was taken after restoration works were completed at Levengrove Park so that the well could be displayed to the public safely.

Screen capture of the 3D model of the well

Created by Rathmell Archaeology for the Galloway Glens, March 2019.

http://www.rathmell-arch.co.uk/

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