

3D Modelling (Photogrammetry)

PART 1: What is it?

What is 3D modelling?

3D modelling is a technique for gathering detailed, measurable data. It is often referred to as Photogrammetry although, strictly speaking, Photogrammetry is a specific type of 3D modelling based on matching stereo-pairs of photographs. 3D modelling is a fantastic method for recording rock art, and has been used increasingly for this purpose in recent years. It is user-friendly and does not require expensive specialist equipment or software, so it is very well-suited for large-scale recording projects. 3D modelling is preferable to other recording methods, such as rubbing or direct tracing, as it is non-invasive and does not need physical contact with the object. The most common 3D modelling method currently used by archaeologists, and in the Scotland's Rock Art Project, is called Structure from Motion (**SfM**).

How does it work?

Capturing 3D data

SfM involves taking multiple, overlapping photographs of an object (what we term 'capturing the data'). The number of photographs required varies depending on the shape of the object and the degree of detail required. Each photograph contains recognisable features that are identified and matched together by specific software.

Creating a 3D model

Creating a 3D model from photographs requires specific SfM software. There are various free on-line versions available – some are listed at the end of this guidance. We will be using a licenced software known as **Agisoft Photoscan**.

The software uses data stored in the images to perform a number of tasks to produce a digital 3D interactive model of the rock surface. The software will calibrate the camera, determine the relative position of the camera in relation to the object, and generate a **sparse cloud** of points by matching the locations of details of the object that appear in two or more photographs. It will then apply what is called a Multi-Viewpoint Stereo (MSV) algorithm, which combines the details of the camera calibration, its position, and the sparse cloud, to build a **dense cloud** which can comprise millions of individual points. The dense cloud is used to create a **meshed model**, formed by combining the positions of the points in the cloud and the matched points from the original photographs. It is also possible (but not essential) to then create a **texture map** by mapping the original pixels from the photographs onto the 3D meshed model.

Our guidance *Processing to Create a 3D Model* takes you through each step in how to use Agisoft Photoscan to produce a 3D model from your field data.

Manipulating a 3D model

Once we have created the meshed model, we can use specific (free) software, such as **MeshLab**, to explore the 3D model by applying different filters and renderings. MeshLab also enables us to highlight or soften the model's surfaces, or to visualize it under different lighting conditions. This makes it possible to identify features on the rock surface, and to search for indistinct carvings. The models can then be shared with others by exporting them as interactive PDFs, or uploading them to internet platforms such as **Sketchfab**.

3D MODELLING**PART 2: In the Field**

This section provides a step-by-step guide for how capturing 3D rock art data in the field, in order to create a 3D model. For guidance on processing to create a 3D model, please see our guidance notes on **3D modelling: Processing 3D Rock Art Data**.

Useful equipment

- ④ **Camera**
Preferably a DSLR camera, but an automatic camera, mobile phone or tablet that can produce high resolution images will work equally well.
- ④ **Tripod**
Not essential, but useful for low light conditions to ensure that your images are sharp.
- ④ **0.5m scale bar**
We will provide ScRAP Teams with Black and White scale bars.
- ④ **Processing software**
Agisoft Photoscan is the best one to use for our purposes. This software requires a licence, and we will provide at least one licence for each ScRAP Team that wants to create 3D models from their photographs.
- ④ **Software for presenting the models**
There are various forms of software that can be downloaded free from the internet. We recommend Meshlab (www.meshlab.net).

Note

It is a good idea to carry either one camera **memory card** with considerable storage capacity (e.g. 16Gb), or more than one memory card, as you never know exactly how many photographs you will need to take that day. Photographing in high resolution will use a lot more space in your card. Similarly, it is also a good idea to carry spare **camera batteries**, as the intensive photography can be heavy on your camera's battery.

Capturing 3D data in the field

Capturing 3D data involves taking multiple photographs of the rock art panel (carved rock surface). The quality of your 3D model entirely depends on the quality and quantity of photographs you take in the field. The following steps provide tips on how to capture good 3D data. Once you start experimenting, you will work out what works best for you.

Note

3D data capture needs different lighting conditions from conventional photography!

1. Preparation

- Make sure that the rock surface you are photographing is clear of vegetation, such as moss, turf, or loose leaves and twigs, as this will interfere with your 3D model. Please

read our guidance notes ***Preparing the Panel for Recording*** for information on how to clean the panel surface without damaging the carvings.

- The panel should be relatively dry, as reflective surfaces confuse the processing software. On a rainy day, it is better to wait for most of the water to drain off the surface. If there is water pooling in any of the carvings, this will cause considerable problems when you create your model. Water can be easily removed from cup marks and grooves with a sponge or cloth.
- Check the lighting conditions. Ideally, the surface should be either completely exposed to sunlight or completely shadowed. Avoid strong contrasts of sunlight/shadow on the surface while taking the photographs as this will confuse the processing software and affect the final result. You can either wait until the lighting conditions are stable (i.e. either consistent sun or consistent shade), or use a tarpaulin, umbrella, or your colleague's shadows to shade the rock surface. It is **very important** to make sure there are no moving shadows on the surface while you are taking the photographs – for example if you are in dappled light under trees.

2. Planning your photography

Have a good look at the panel and decide where to take your photographs, and how many to take. You should aim for the following:

Coverage: Your photographs should cover the whole rock surface. If large parts of the panel surface are not carved, or if the rock has several un-carved surfaces, please photograph these in addition to the carved areas, so that your model includes the whole 3D shape of the rock. You can take fewer photographs of un-carved areas, and more of carved areas, so that there is greater detail for the carvings.

Consistency: It is important that your photographic coverage is consistent in order to avoid gaps in your model.

Quantity: The more photographs you take, and the closer you are to the rock surface, the more detailed your 3D model will be. The number of photographs you take will depend on:

- (a) The size of the panel (larger panels and/or panels with more exposed surfaces will need more photographs to ensure full coverage)
- (b) The extent and complexity of the carvings (panels with extensive, complex carvings will need considerably more photographs than panels with one or two cupmarks, for example). The carved areas need to be covered in more detail than the uncarved surfaces (you can capture more detail by standing closer to the relevant part of the rock surface).
- (c) The level of detail required.

As a rough guide, you should aim to take between 40 and 70 photographs, although large, extensively carved panels may need more than 70 photographs to produce a detailed 3D model. As you become more familiar with the technique, you will be able to judge how many photographs are best for each panel you record.

Once you have planned your photography session, you are ready to start!

3. Taking the photographs

Setting your camera:

- Put your camera on the highest resolution setting (this will vary between cameras)
- You should aim not to use your zoom. It is **very important not to change the zoom** during the photography session
- Apertures and ISO will depend on the conditions on the day you do the recording, so it may be easiest to simply use the camera on automatic mode.
- If you have a choice, set your camera to take .jpgs.
- If the light conditions are dim (e.g. on a very dull winter day, or at twilight), it is best to use a tripod so that your images remain sharp.

Capturing the rock art data:

- Place the 0.5m scale bar next to the rock surface. Ideally this should be located to the side of the panel, rather than on top of it, unless there is no other option. If you need to place the scale bar on the rock surface, make sure that it does not cover any motifs. Alternatively, you can place a ruler or tape measure beside or on the panel. Remember that your scale needs to appear in at least three photographs. Do not move the scale bar during your photography session.
- You should aim to keep a constant distance from the rock surface, and not zoom in on the carvings. We recommend that a distance of about **1m** away is suitable for many panels, but this will depend to some extent on the size of the rock surface – for example, you will need to stand closer to small panels, or to capture detail of carved areas, and further back to photograph uncarved areas of larger rock surfaces. You should also aim to minimise the extent to which the area around the panel appears in your photographs. This is unwanted information and, although it can be removed during the processing, it is better to reduce it at the data capture stage.
- Your camera must always be positioned perpendicular to the surface you are recording, as shown in Figures 1 and 2. As you move around the panel, you may need to change the position of the camera so that it is consistently perpendicular to the rock.

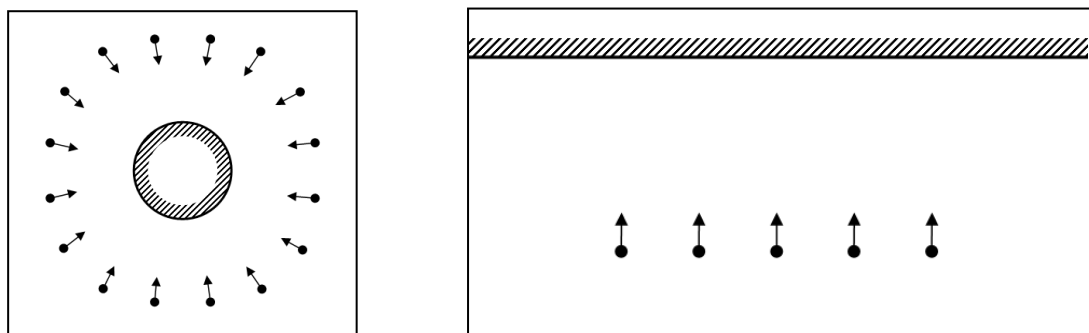


FIGURE 1. You can photograph the rock surface by capturing a sequence of parallel photographs or adopting more of a 'dome' strategy, in which the carved rocks is enveloped in photographs (right).

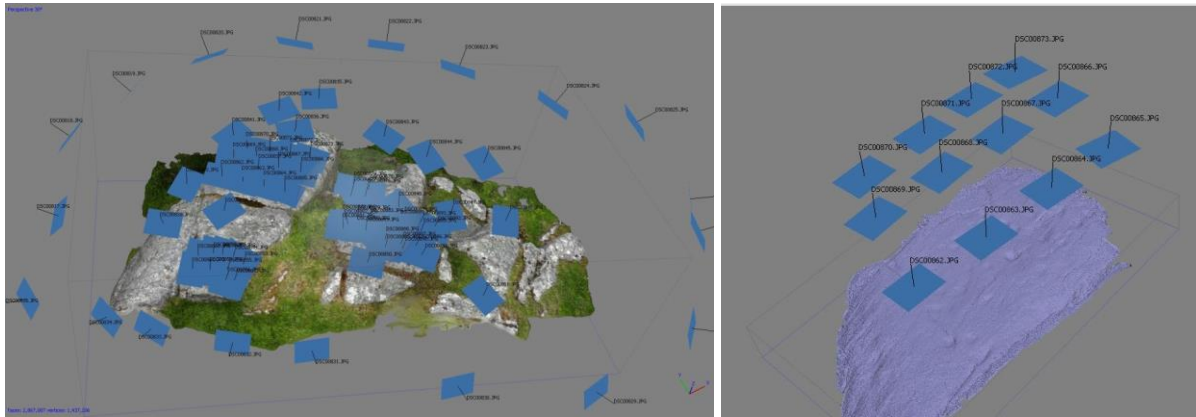


FIGURE 2. In this model of Cnoc Bhiosta (Tiree), photographed by Alan Thompson (NOSAS), the whole rock art outcrop was enclosed by the photographs in a 'dome' (left) and the carved area covered by a parallel sequence (right). Each blue rectangle shows the position of the camera from which the photographs were taken.

To create a successful model, it is crucial that there is a significant overlap between your images so that common points can be matched together. Ideally, adjacent photographs should overlap by about a third of your field of view, following a linear direction (Figure 3).

- a. For flat surfaces, repeat this process in rows from one end of the rock to the other
- b. For surfaces that are not flat, take your overlapping photographs following an imaginary spiral around the panel to form a dome shape, closing at the top.

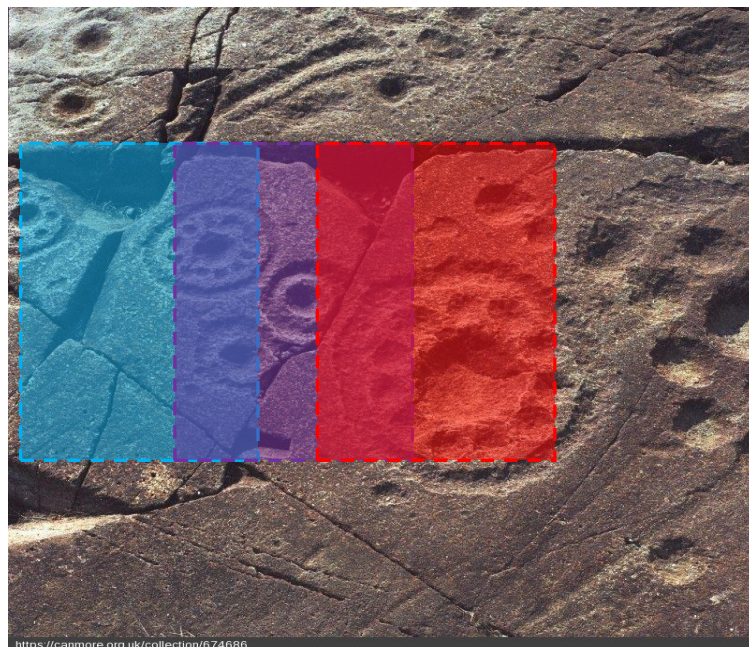


FIGURE 3. Example of a sequence of three photographs used to build a 3D model of a carved rock. Notice the extent of overlap between the adjacent photographs (red, purple and blue rectangles).


Note

In practical terms you can give a small sideways step after each shot, making sure that when you shoot the next image, you include about a third of the rock surface in the previous image.

- Once you have completed your photographs, make a note of the image numbers and the panel name and number on your photography recording sheet, or in your notebook. It is very important that you do this as soon as you have finished, particularly if you are recording several panels on the same day, as it is extremely easy to lose track of which images relate to which panel.

Well done! You are now ready to process your images to create a 3D model, or to send us your images to process.

3D modelling software

Free 3D processing software

We would like all 3D models that you upload to our database to be created in **Agisoft Photoscan**. Following training, we will provide Agisoft Photoscan licences to specific people in each Community Team to enable the teams to create 3D models.

You can download a 30-day free trial version of the software from the Agisoft website:

<http://www.agisoft.com/>.

If you are interested in trying out other types of 3D processing software, there are various free versions available for download from the internet, including:

Regard3D: <http://www.regard3d.org/>

VisualSFM: <http://ccwu.me/vsfm/>

3DFlow: <https://www.3dflow.net/3df-zephyr-free/>

Autodesk 123DCatch: <https://autodesk-123d-catch.en.softonic.com/?ex=DSK-309.0>.

For more information, see: <https://pfalkingham.wordpress.com/2016/09/14/trying-all-the-free-photogrammetry/>

Free ways to manipulate and share your 3D model

Meshlab: <http://www.meshlab.net/>

Sketchfab: <https://sketchfab.com/>