



# Structure from Motion (SfM) Photogrammetry

## What is SfM Photogrammetry?

Today, SfM Photogrammetry is used in a wide range of fields from topographic mapping to the movie and gaming industry and it is increasingly used for cultural heritage preservation by archaeologists. It provides a rapid, extremely versatile and cost-effective tool for recording and analysing complex objects and surfaces using computer software which turns a sequence of two-dimensional digital photographs into a three-dimensional model. Under suitable conditions, the technique is a powerful method of capturing high-resolution georeferenced three-dimensional surfaces with complete textures and sub-centimetre accuracy. It can be applied to photographs taken during archaeological excavations, building surveys and laboratory conservation.

The software looks for points of commonality in overlapping photographs of a single object or surface from which it can extrapolate virtual camera positions and a three-dimensional point cloud (right, a) which can be converted to a polygon mesh (b). The photographs can then be used to render the surface reconstruction to create a photo-realistic effect (c).

Archaeologists use SfM Photogrammetry for a variety of outputs:

- To create a plan of a feature or area (to replace a hand-drawn plan)
- To produce a section or profile across a feature or area (to replace a hand-drawn section drawing)
- To create a digital terrain model (DTM) or digital elevation model (DEM) – in this way it can be used similar to LiDAR.
- To produce a complex 3D model to aid analysis of the archaeological sequence.
- To produce a 3D model for educational purposes, providing a fun and interactive tool that can be used in the classroom by schools to study archaeological material that is no longer accessible, or is only accessible in museums.

**REMEMBER:** Think carefully about what your desired outcomes are for the model, then tailor your survey accordingly. If you only need a simple plan of a spread of stones you will need fewer photographs than you would for a complex model of a large area.

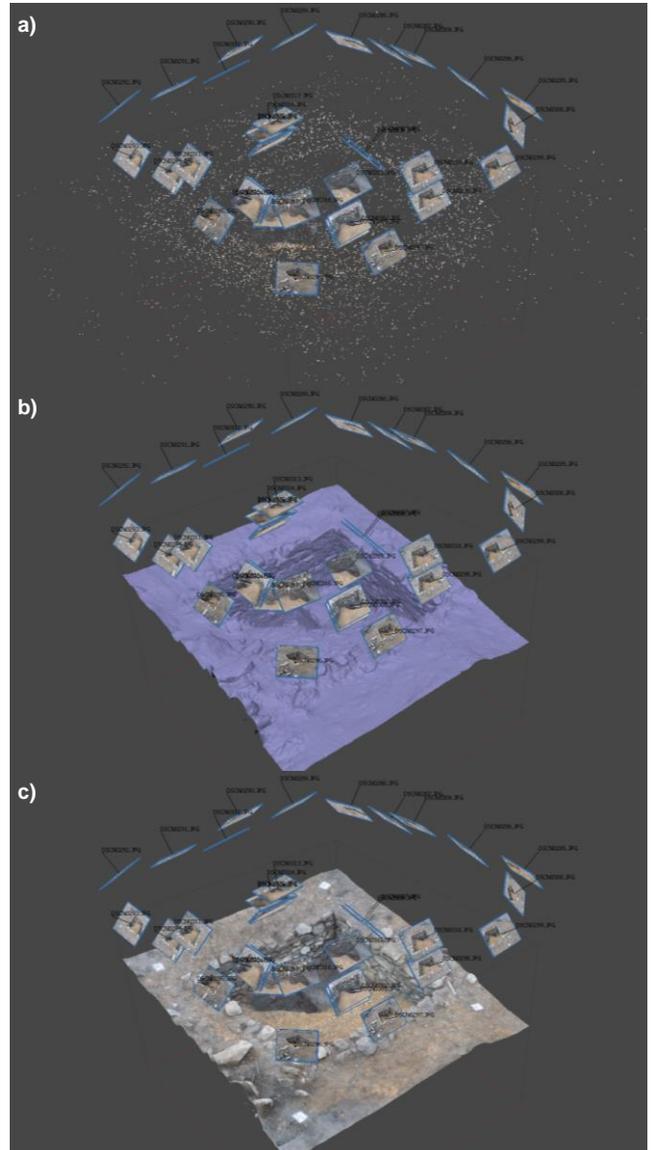
### What equipment will I need?

- A good digital camera or camera phone
- Georeference markers
- Close range SfM Photogrammetry software

## Where can I get SfM Photogrammetry software?

There are many photogrammetry software tools available. Some are professional, requiring a licence and having an often high associated cost, but there are good open source photogrammetry tools available too. The following is a list of available software. The Leicestershire Fieldworkers has not tried all of these programmes and cannot guarantee that they are all suitable for archaeological recording.

- **COLMAP** <https://colmap.github.io/index.html#> FREE
- **MESHROOM** <https://alicevision.github.io/#meshroom> FREE
- **MICMAC** <https://micmac.ensg.eu/index.php/Accueil> FREE
- **OPENDRONEMAP** <https://www.opendronemap.org/> FREE
- **REGARD3D** <http://www.regard3d.org/> FREE
- **VISUALSFM** <http://ccwu.me/vsfm/> FREE
- **3DF ZEPHYR** <https://www.3dflow.net/> FREE VERSION & TRIAL
- **AGISOFT METASHAPE** <https://www.agisoft.com/> FREE TRIAL
- **AUTODESK RECAP** <https://www.autodesk.com/products/recap/overview> FREE TRIAL
- **iWitnessPRO** <https://iwitnessphoto.com/> FREE TRIAL
- **PHOTODELER** <https://www.photodeler.com/> FREE TRIAL
- **REALITYCAPTURE** <https://www.capturingreality.com/Home> FREE TRIAL



Modelling a medieval stone-lined pit at Highcross Street, Leicester. Using SfM photogrammetry Agisoft Metashape. Image: ULAS



# How to record using SfM Photogrammetry

## Prepare the feature / area

- Clean the feature and tidy up the immediate area.
- Include 3-8 georeference markers, a small scale, north arrow and context number. **TIP:** Keep these to the side out of the way so they can be cropped / removed from the model at a later date if required.

## Lighting & weather conditions

- Cloudy dry days are best. Make sure that there are no shadows. Partial rain can create varying colours on stones, ideally photograph only damp or dry archaeology.

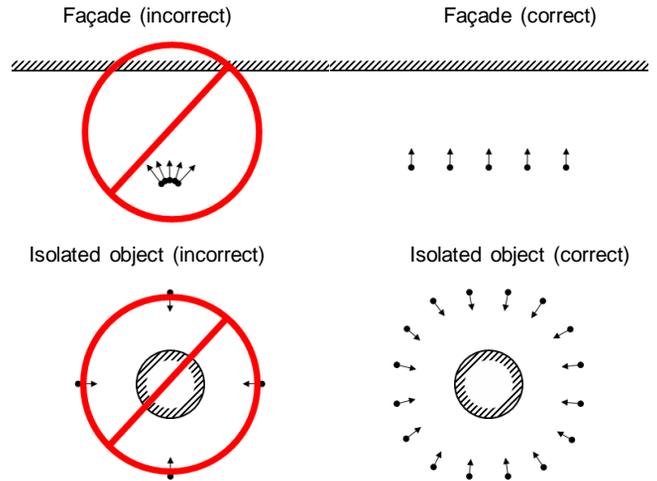
## Camera Settings

- Use a high resolution camera, ideally a DSLR. Check highest quality settings are selected (e.g. RAW+jpg).
- Shoot in manual mode, only vary the shutter speed.
- Shoot at a high F-number (e.g. f/9 - f/22) to ensure all of the subject is in focus.
- Shoot at a low ISO (e.g. 100-300) to reduce grain on the images.
- **TIP:** If you do not have a digital camera, a good camera phone can also produce excellent results.

## Carrying out the photo survey

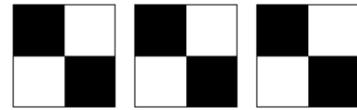
- Plan your photo locations. You need to take a sequence of overlapping photos with each photo in a different location with an overlap of around 60%. This is the **MOST IMPORTANT** rule of photogrammetric recording. The higher the percentage of matched area, the greater success the software will have matching points and creating a higher quality model.
- **TIP:** A simple way to achieve this is to photograph, sidestep, photograph, sidestep, photograph, sidestep etc.
- Take photos as you walk all the way around the feature / area. You need to be roughly the same distance and height from the feature at all times.
- **REMEMBER:** Look for hard to see points and blind spots. Repeat the circuit at higher and lower angles to capture hidden areas as required. Do close-ups on areas that have particularly important details.
- Always use landscape orientation if possible and do not zoom in.
- Whilst the entire feature / area does not need to be in every photo, photos should be taken with good focus of most of the subject area. This increases the amount of points that can be detected, and therefore increases the quantity of the model.
- Avoid photographs with moving objects (e.g. other archaeologists, random animals, etc.).

The following diagrams show the appropriate methods for capturing features / areas.



## Georeferencing the survey

- If you want to use the model to create a plan or section of your feature / area, the survey will need to be georeferenced by including **AT LEAST** three survey markers at various points around the feature.



- **TIP:** For the best outcome, place 6-8 markers around the feature, covering a variety of heights.
- Add more markers if needed for large features / areas.
- Make sure the markers are accurately located with a grid co-ordinate and spot height, either using dGPS / EDM, or in relation to a site grid and temporary bench mark (using surveyors tapes and a dumpy level).
- Only remove the markers once you have downloaded and checked the survey data and processed the model.

## Other things to consider

- If you are creating multiple models, have an index sheet for them in your site indices.
- If you are using SfM photogrammetry to replace hand-drawn plans and sections you will need to devise a pro-forma recording sheet, ideally including an annotated print out or sketch of the model, site code, context number etc.
- Show the georeferenced markers and their co-ordinates on the plan on the recording sheet.
- Add structure / feature details that would usually be included on a measured hand-drawn plan.
- Add extra height information as needed (to show slope or other discrete height differences) as you would on a measured hand-drawn plan.
- Data processing will depend on the software you are using.

## Further Reading

Historic England (2017) *Photogrammetric Applications for Cultural Heritage: Guidance for Good Practice*  
<https://historicengland.org.uk/images-books/publications/photogrammetric-applications-for-cultural-heritage/>