The National Museum of Computing
Make a Historical Replica

This sheet takes you through the basics of photogrammetry.

What is photogrammetry?

The science of taking measurements from photographs. This process can be used to make a point cloud or mesh of an object which is in turn used to create a 3D model. This model can then be turned into code for a 3D printer.

It is not easy or quick, but it is do-able. It would be a fun project for gifted and talented Key Stage 2 & 3, GCSE or 'A' Level groups.

You will need

- A camera - a smartphone camera or DSLR camera will work
- A computer with a Cuda enabled NVidia GPU with a compute capability of 2.0 or more.
- Download Meshroom onto your computer. This program is free open source software. It doesn't need an installer so you do not need permissions to install and run it https://alicevision.org/#meshroom

Step 1 - Choose what you want to copy

Ideal items for photogrammetry have:
- textured or rough surfaces
- lots of depth contrast in the item. The flatter the surface the harder it is to create a suitably detailed map of the item.

Step 2 - Take lots of photographs

- You will need to take a minimum of 100 photographs to capture every detail.
- Don't be afraid to take multiple photographs of the same thing. This information will help with mapping.
- If you are using a DSLR camera adjust the depth of field to make sure the whole frame is in focus.
- Move around the target object in circles taking photos rather than moving the object. The computer will use the background surroundings to triangulate the image so if you move the object you will confuse this process.
- Vary the height of photo each time you go around the object to ensure you capture lots of detail. The object you want to map should make up at least 25% of the photograph.
- Avoid hard shadows - use even lighting from all sides

Step 3 - Create a 3D mesh reconstruction

- Make 2 folders; Photos, for your photographs and Output, for the output from Meshroom.
- Copy all your photographs into the Photos folder
- Drag and drop the folder of photographs into Meshroom window
- Save the project into the Output folder (otherwise it will go into a temp folder)
- Click start. It can take a while to get going. There is a program bar which will turn green and then orange as the program progresses.
- If the bar turns red you will need to check the photograph window to see which images have been accepted by the program. You may want to add images to areas where lots of images have failed.
- Once all the photographs have been matched, they will have a green tick next to them. A preview of the model can be seen in the window. If this looks OK, you can compute. If not, you might want to take some more photographs or fine tune the settings.
- The reconstruction can take several hours to run so you may want to leave it overnight.

Step 4 - Tidy your model

Once the reconstruction has been made you may want to tidy it up. You can use your slicer or a 3d design program like Blender to:
- Delete unwanted parts of the model
- Infill any missing items
- Create a base for the item

Step 5 - Create a printable copy of your model

- Once edited the reconstruction can be saved as an .obj or .stl file. You can then put this file into a slicer program to turn it into G-code or other 3D printer compatible files. Check your slicer is set to render the file in the correct format for your 3D Printer.
- When the file is in the slicer you may have to resize the object as it can sometimes come out very large or very small. Ensure that it is the right size for you.
- You will also need to ensure that the base is flat to the bed. It is possible to print multiple files in one by putting them through the slicer at the same time. This will put them together in the same G-code file. The upside is that you can batch print. The downside is that if an object does not print well it can disrupt the whole print run.
- Transfer the G-code file to the printer

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Sounds simple! If you have never done anything like this before it can be quite intimidating and confusing at first but there are lots of videos online to help you with more detail.

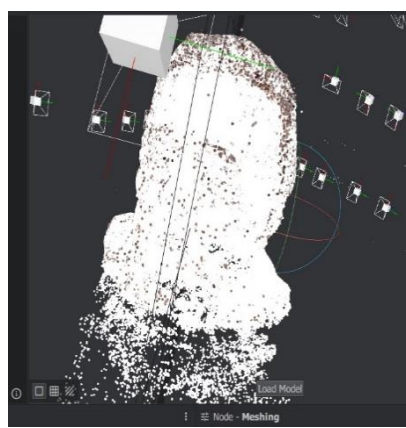Here's a couple to get you started: -

Basic tutorial on Photogrammetry - https://www.youtube.com/watch?v=1D0EhSi-vvc
Tutorial on how Meshroom works - https://www.youtube.com/watch?v=RmMDFydHeso

Recreating a bust of Charles Babbage
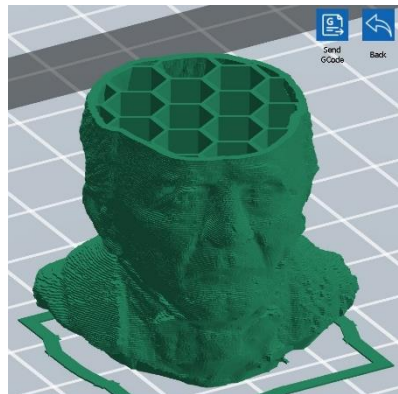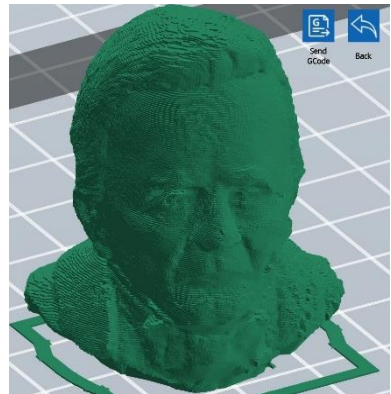

Original

3D Mesh Point Cloud

3D CAD file

Sliced image showing inside

Complete sliced image

Actual Printed Replica