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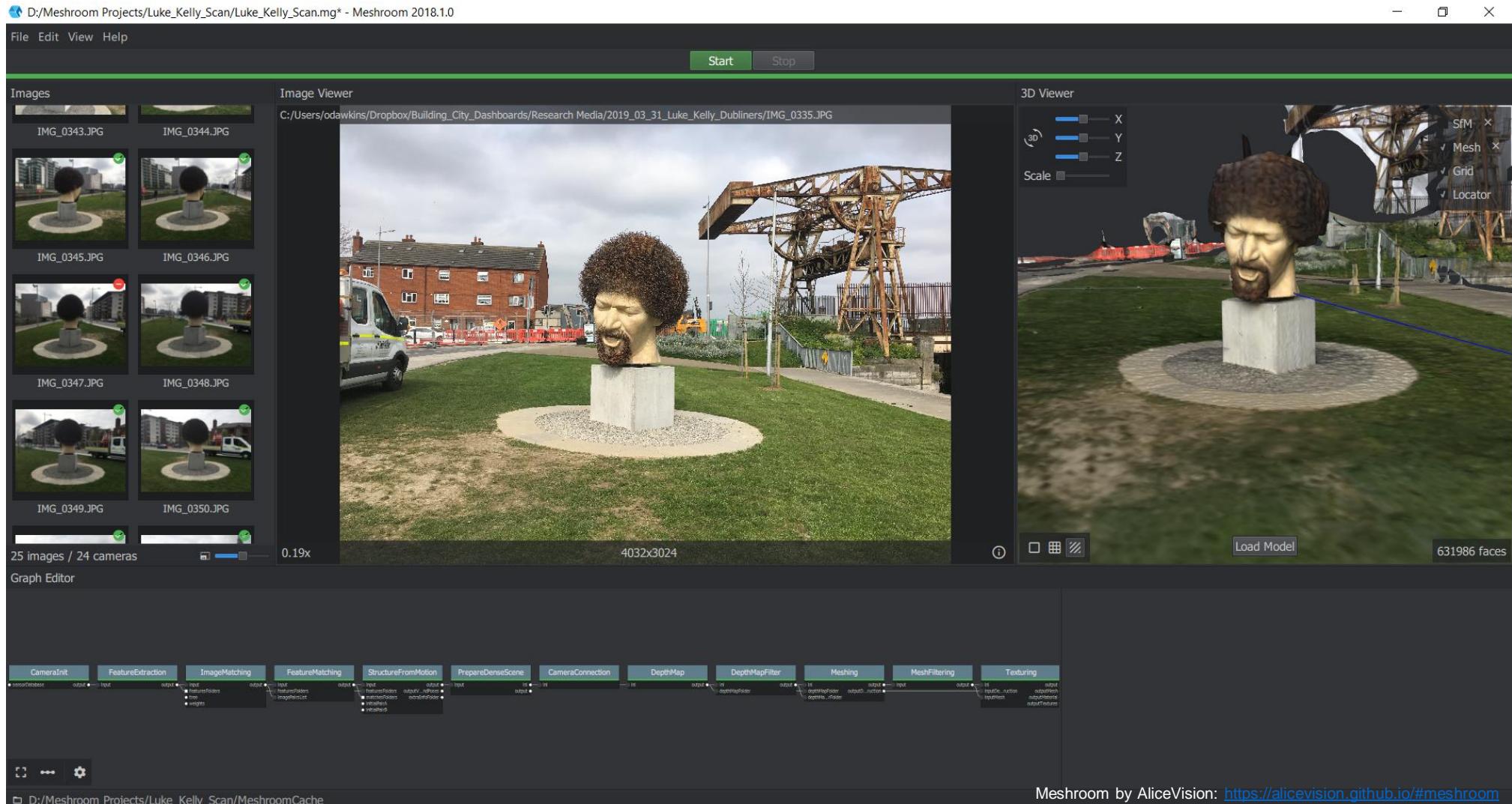
[dashboards.maynoothuniversity.ie](http://dashboards.maynoothuniversity.ie)  
[@dashbuild](mailto:dashboards@mu.ie)

## Creating 3D Models with Photogrammetry and Structure from Motion using Meshroom

**OLIVER DAWKINS**



# Structure from Motion (SfM) with Meshroom





# Photogrammetry with Meshroom

- Photogrammetry is the process of making measurements and determining positions of objects from photographs: <https://en.wikipedia.org/wiki/Photogrammetry>
- Structure from Motion (SfM) is the process of estimating the structure of a 3D object from a sequence of 2D images: [https://en.wikipedia.org/wiki/Structure\\_from\\_motion](https://en.wikipedia.org/wiki/Structure_from_motion)
- Meshroom is Free and Open Source software which means you can download and use it without paying. It is free to use!
- It is also very user friendly compared to other open source solutions because it has been developed for previsualisation and visual effects in the film industry
- System Requirements:
  - Windows or Linux operating system (Mac not currently supported)
  - Recommended for use with NVIDIA CUDA-enabled GPU (compute capability v2.0 +). Check GPU compatibility here: <https://en.wikipedia.org/wiki/CUDA>
  - Minimum RAM of 8GB although 32GB is recommended for 3D meshing

**NOTE:** If a CUDA-enabled GPU is not available it is possible to use your computer's CPU instead with Meshroom's 'Draft Meshing' (see below). Results will be dependent of your CPU's capabilities.



# Taking Digital Photos for SfM

- Try to take pictures from all angles
- Take overlapping images
- Fill each image with the object
- Include the background to help identify camera orientation
- The object or area should be well lit
- Ideally shoot in indirect light
- Don't use flash
- Avoid reflections and transparent objects
- Avoid single coloured surfaces
- You can take photos of the same object in different patterns to avoid blind spots
- You can take close-ups for added detail
- Scenes with moving objects don't work
- More images are better than less. Images that don't work can be omitted later.
- Avoid changing focal length and shallow depth of field
- Consider using manual settings (may require a different camera app)
- Consider using a tripod

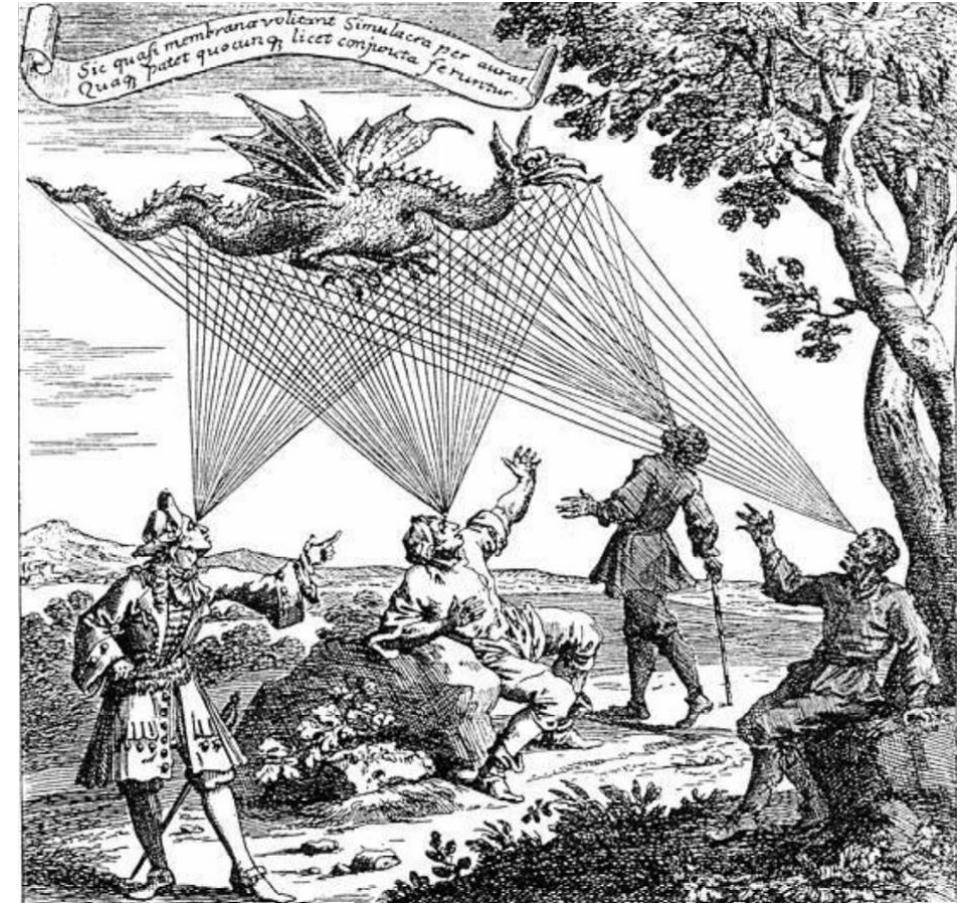
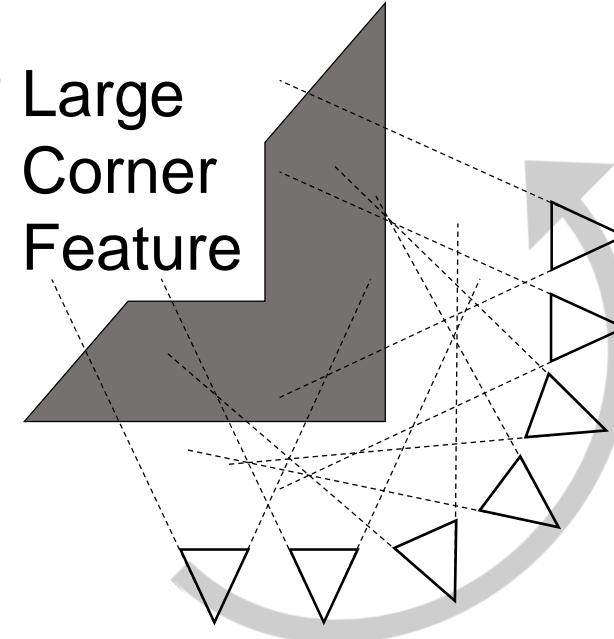
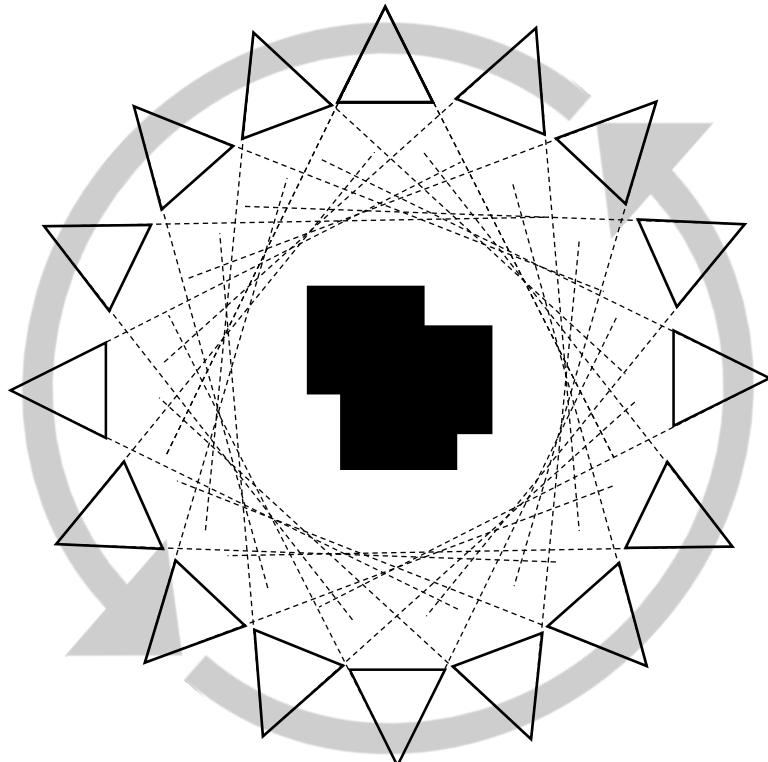


Illustration from *Oculus artificialis teledioptricus sive Telescopium*, 1610  
Image via AliceVision: <https://alicevision.github.io/index.html#history>

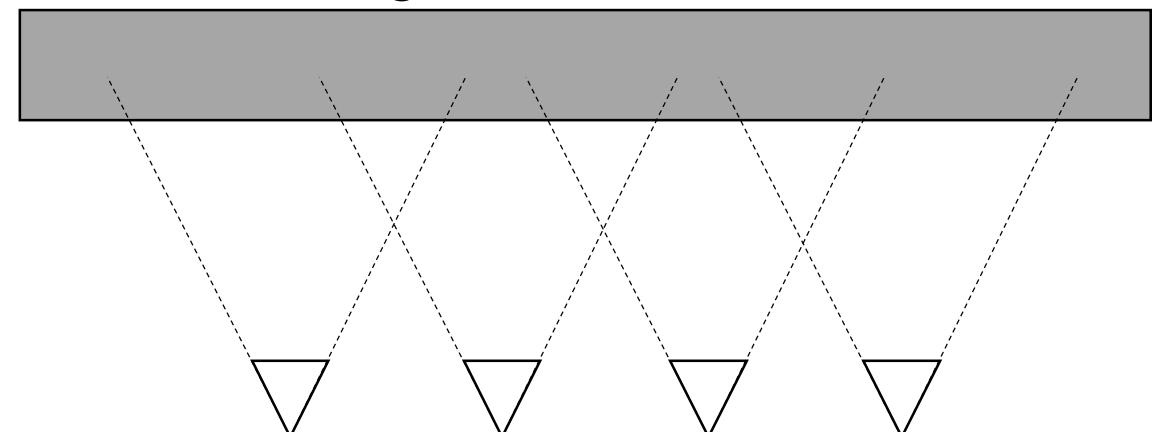


# Image Capture Strategies

Full 360° Capture



Large  
Corner  
Feature





# Online Hosting via Sketchfab



Sketchfab EXPLORE BUY 3D MODELS FOR BUSINESS Search 3D models

York Minster Bronze Model  
3D Model

virtualarchitectures FOLLOW

Add To Embed Share

Triangles: 576.8k Vertices: 289.8k More model information

A photoscan of the bronze model of York Minster which was designed to be tactile and incorporates braille for blind and partially sighted visitors.

York Minster Bronze Model by Virtual Architectures on Sketchfab:  
<https://sketchfab.com/3d-models/york-minster-bronze-model-4b95fa350db7426ba4b67413d143dbb2>



# Download and Install Meshroom

AliceVision

HOME MESHROOM PHOTGRAMMETRY HISTORY RESULTS CONTRIBUTING ABOUT US

1. Click to download the latest release for Windows.

Meshroom is a free open-source 3D Reconstruction Software based on the AliceVision framework.

[Meshroom 2019.1.0 64-bit](#)

[Meshroom 2019.1.0 64-bit](#)

[Github](#)

2. Extract the downloaded files to **C:\Program Files\Meshroom** or another location of your choice.

Meshroom: <https://alicevision.github.io/#meshroom>



# The Meshroom User Interface

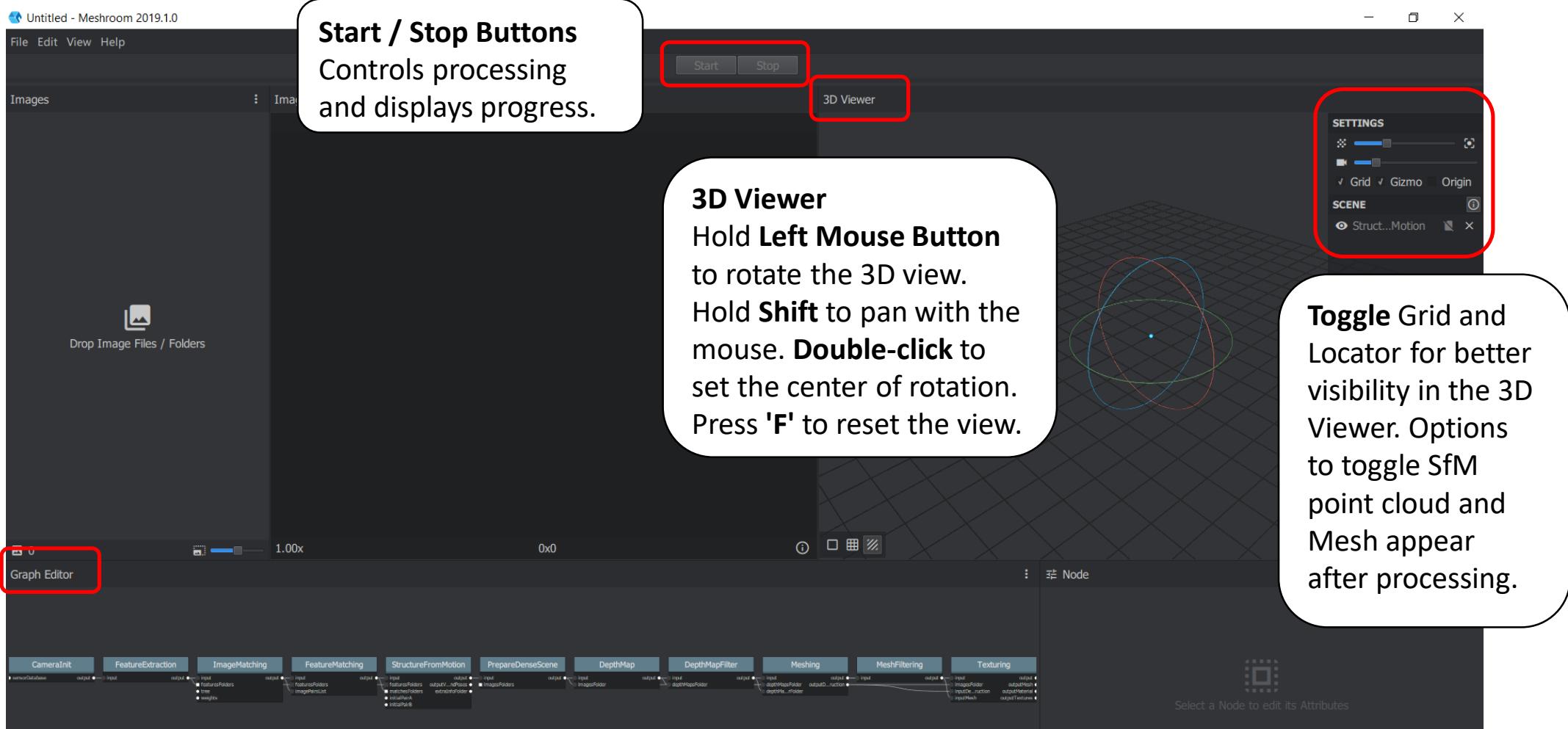
The screenshot shows the Meshroom 2019.1.0 application window with several panes highlighted by red boxes:

- Images Pane**: Drag and drop images to be processed here.
- Image Viewer Pane**: View images.
- 3D Viewer Pane**: Displays SfM pointcloud, cameras and mesh in 3D.
- Graph Editor Pane**: Node-based editor used to control the SfM processing.
- Properties Pane**: Displays user configurable properties of any node selected in the Graph Editor.

The Graph Editor pane at the bottom left shows a complex network of nodes and connections, including CameraInit, FeatureExtraction, ImageMatching, FeatureMatching, StructureFromMotion, PrepareDenseScene, DepthMap, DepthMapFilter, Meshing, MeshFiltering, and Texturing. The Properties pane on the right shows settings for a selected node, including checkboxes for Grid, Gizmo, and Origin, and a list for SCENE.

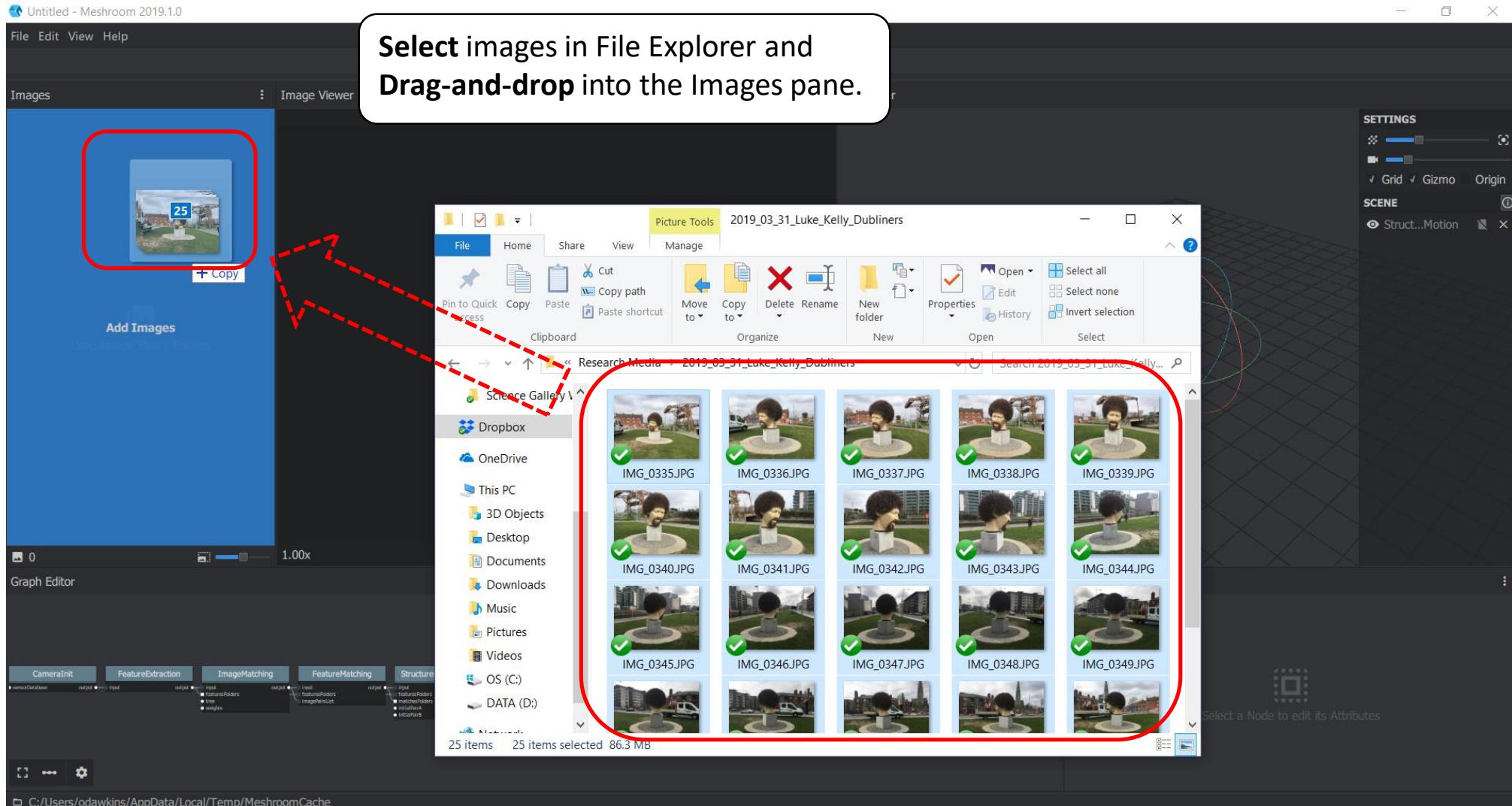


# The Meshroom Controls





# Load Images for Processing





# Check and Remove Blurry Photos

Select each photo in turn in the Images pane and review in the image viewer.

To remove a blurry image **right click on the image** in the Images pane and select '**Remove**'.

Untitled\* - Meshroom 2019.1.0

File Edit View Help

Start Stop

Images

Image Viewer

C:/Users/odawkins/Dropbox/Building\_City\_Dashboards/Research Media/2019\_03\_31\_Luke\_Kelly\_Dubliners/IMG\_0338.JPG

3D Viewer

SETTINGS

Grid Gizmo Origin

SCENE

Struct...Motion

Node

TopFilter Meshing MeshFiltering Texturing

Select a Node to edit its Attributes

C:/Users/odawkins/AppData/Local/Temp/MeshroomCache



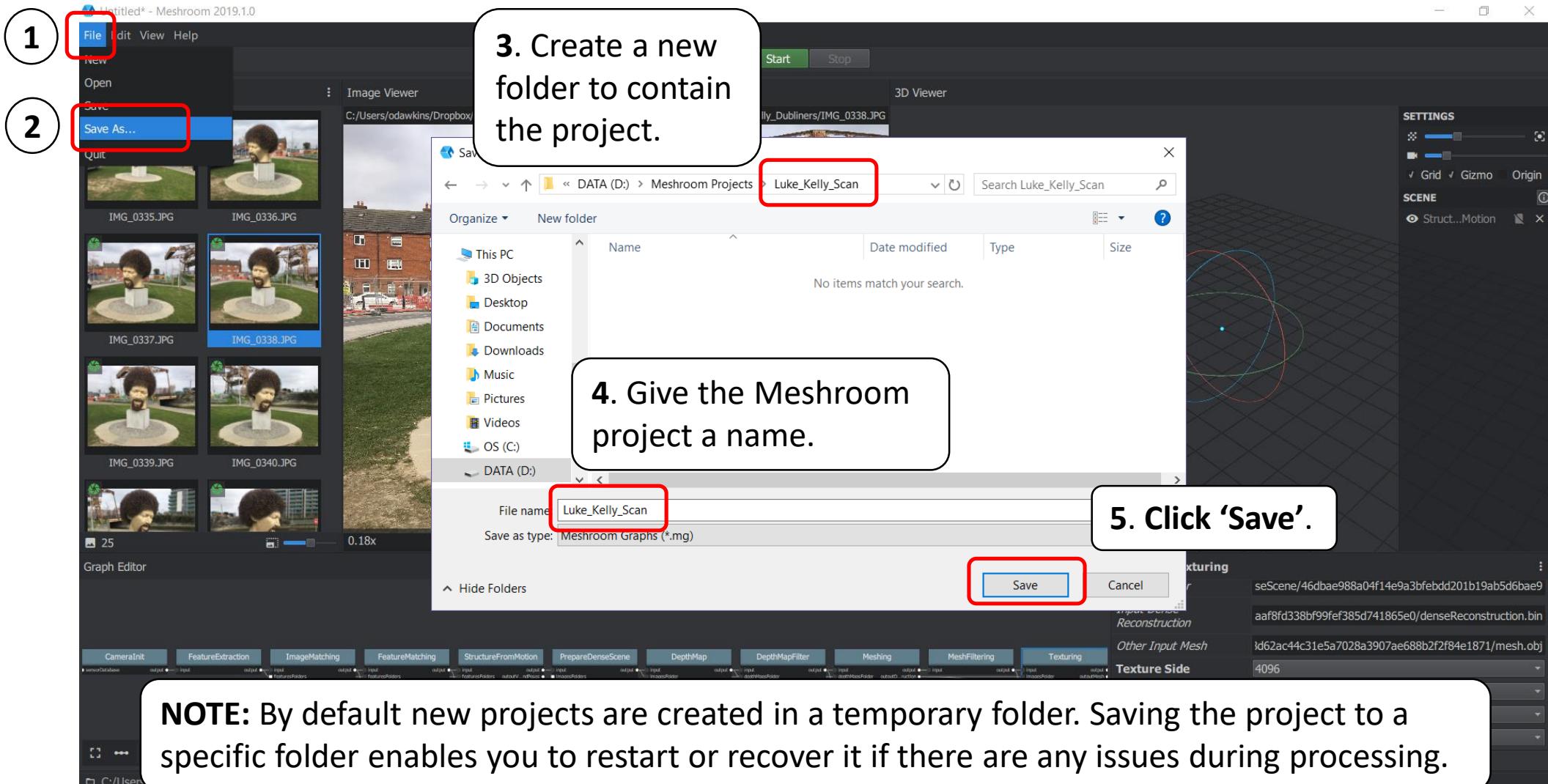
# Set Texture Output Settings

In the properties pane...

1. Select the '**Texture**' node in the Graph Editor.
2. Reduce the **Texture Side** parameter to '**4096**' or less to output a less detailed but more performant texture for interactive visualisation.
3. Set the **Unwrap Method** to '**LSCM**'. This is important to ensure that a single texture is created for the 3D mesh.



# Save Each New Project Before Processing





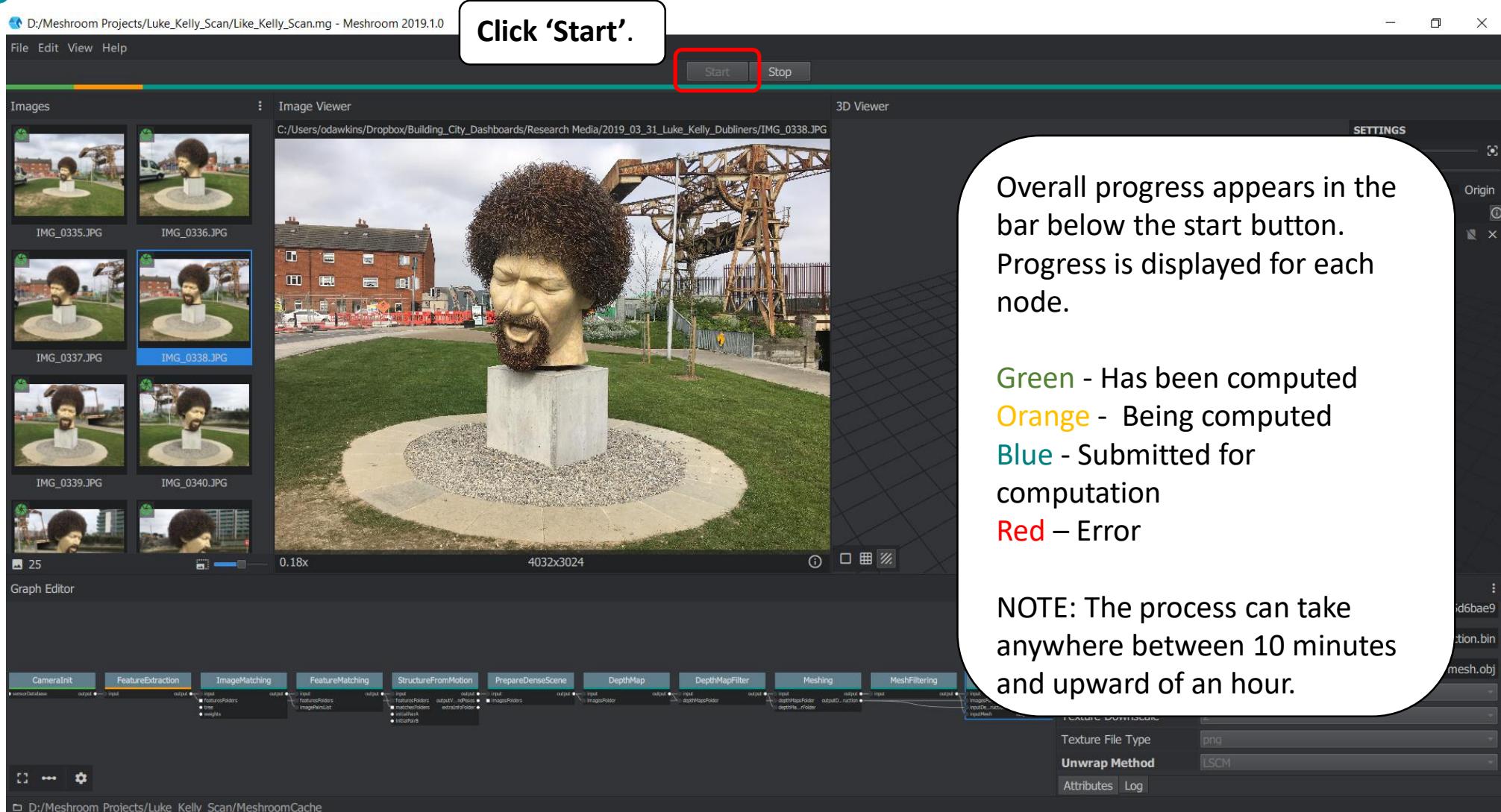
# GPU Processing with NVIDIA CUDA

- Meshroom was initially designed for use with high end graphics cards which can perform high quality meshing on the GPU
- To take advantage of the software's full capability you will need a **CUDA-enabled NVIDIA GPU with compute capability of 2.0+**
- You can check the compute capability of your NVIDIA video card on this Wikipedia page: <https://en.wikipedia.org/wiki/CUDA>
- The process for using this capability is outlined in the following slide.

**NOTE:** If you do not have a CUDA enabled video card **you can still use Meshroom's 'Draft Meshing' capability to get a usable 3D Mesh.** Skip ahead to the slide 'CPU Processing' below for more details.

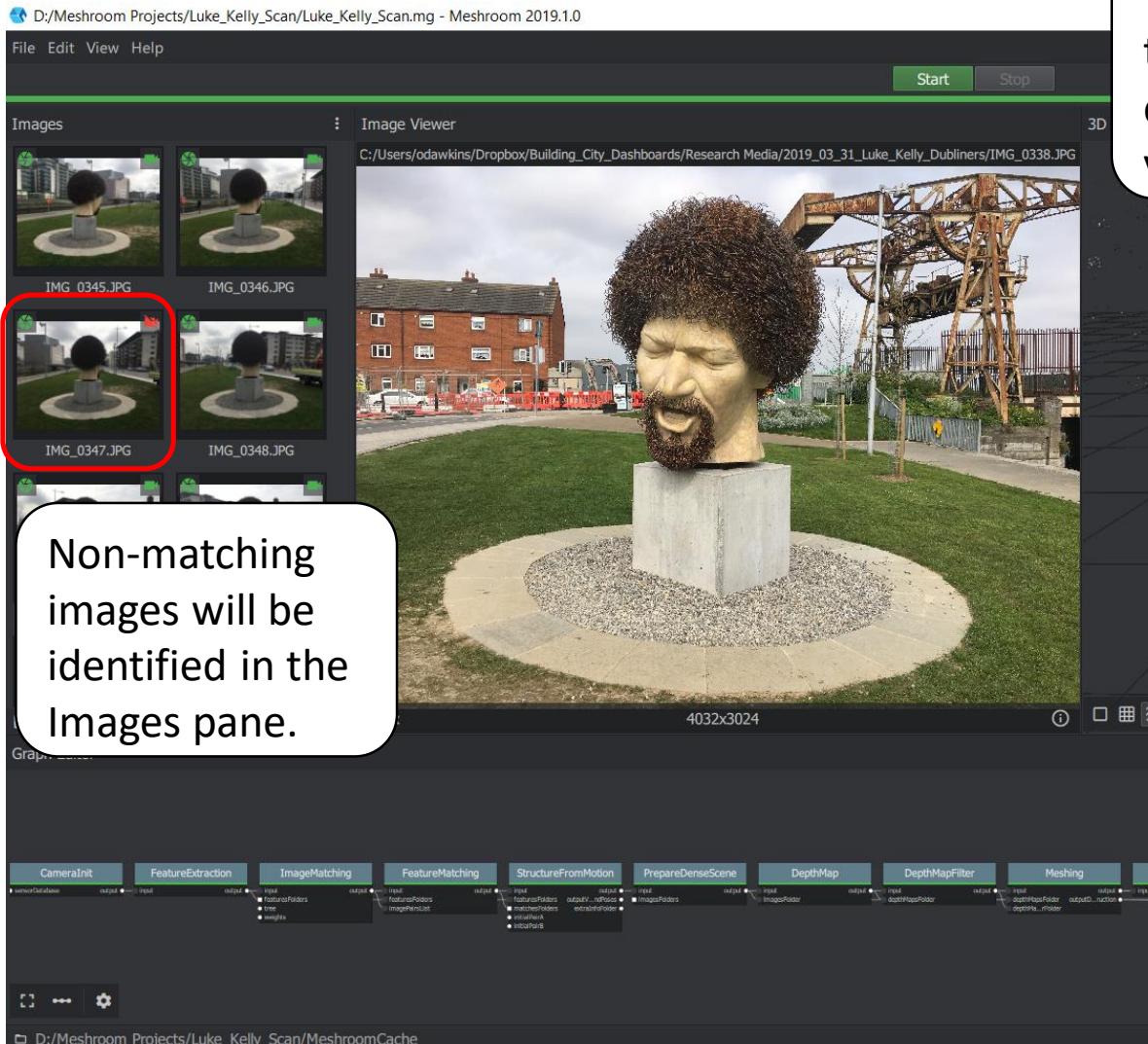


# Start GPU Processing

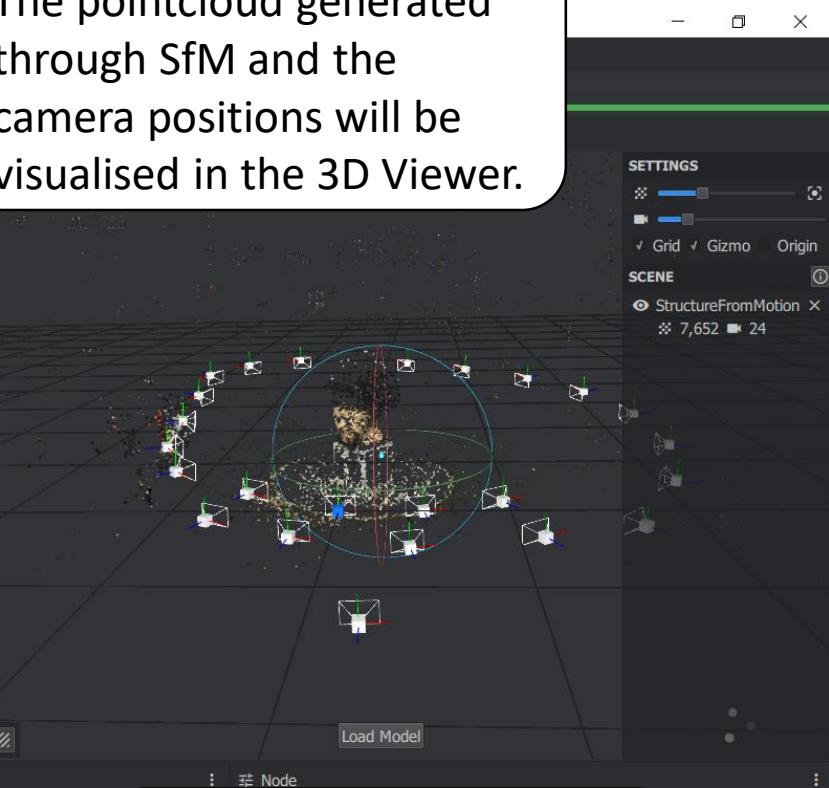




# Review SfM Pointcloud



The pointcloud generated through SfM and the camera positions will be visualised in the 3D Viewer.



Click 'Load Model' to load the generated mesh into the 3D Viewer.



# Review the Mesh Output

D:/Meshroom Projects/Luke\_Kelly\_Scan/Like\_Kelly\_Scan.mg - Meshroom 2019.1.0

File Edit View Help Start Stop

Images

Image Viewer

C:/Users/odawkins/Dropbox/Building\_City\_Dashboards/Research Media/2019\_03\_31\_Luke\_Kelly\_Dubliners/IMG\_0338.JPG

3D Viewer

SETTINGS

SCENE

StructureFromMotion  
7,652 24

Texturing  
658,463 1

Graph Editor

Node - Texturing

Images Folder: seScene/46dbae988a04f1e9a3bfebdd201b19ab5d6bae9

Input Dense Reconstruction: aa8fd338bf99fe385d741865e0/denseReconstruction.bin

Other Input Mesh: 1d62ac44c31e5a7028a3907ae688b2f2f84e1871/mesh.obj

Texture Side: 4096

Texture Downscale: 2

Texture File Type: png

Unwrap Method: LSCM

Attributes Log

25 24 0.18x 4032x3024

CameraInit FeatureExtraction ImageMatching FeatureMatching StructureFromMotion PrepareDenseScene DepthMap DepthMapFilter Meshing MeshFiltering Texturing

Dashboard

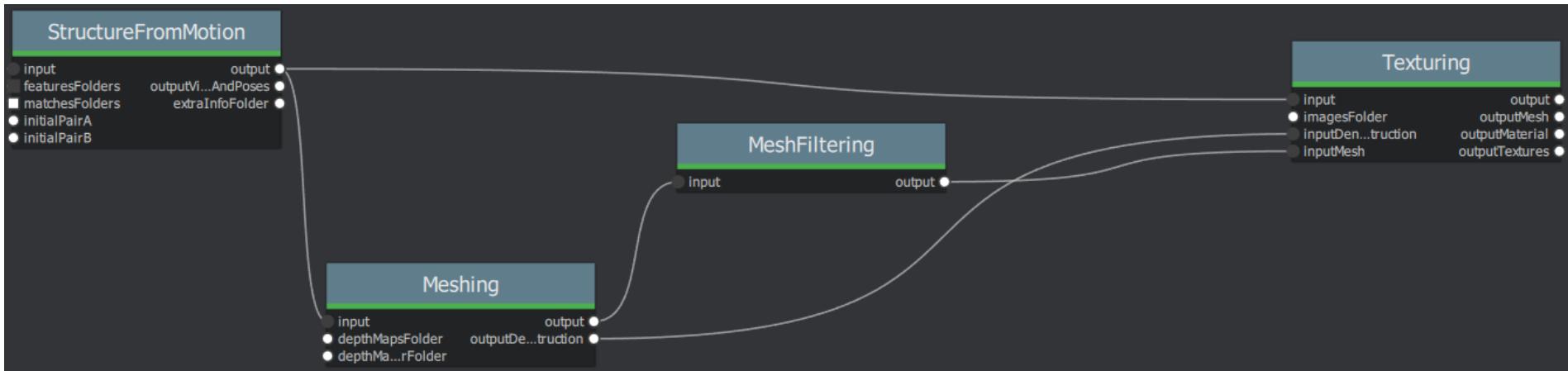
D:/Meshroom Projects/Luke\_Kelly\_Scan/MeshroomCache

A callout box highlights the "SCENE" section in the SETTINGS panel, which contains two items: "StructureFromMotion" and "Texturing". The "Texturing" item has a red border around it.



# CPU Processing

- If you do not have a supported video card you can still use Meshroom
- Since version 2019.1.0 Meshroom supports Draft Meshing
- This process bypasses the Meshroom DepthMap node and uses the CPU rather than GPU for meshing

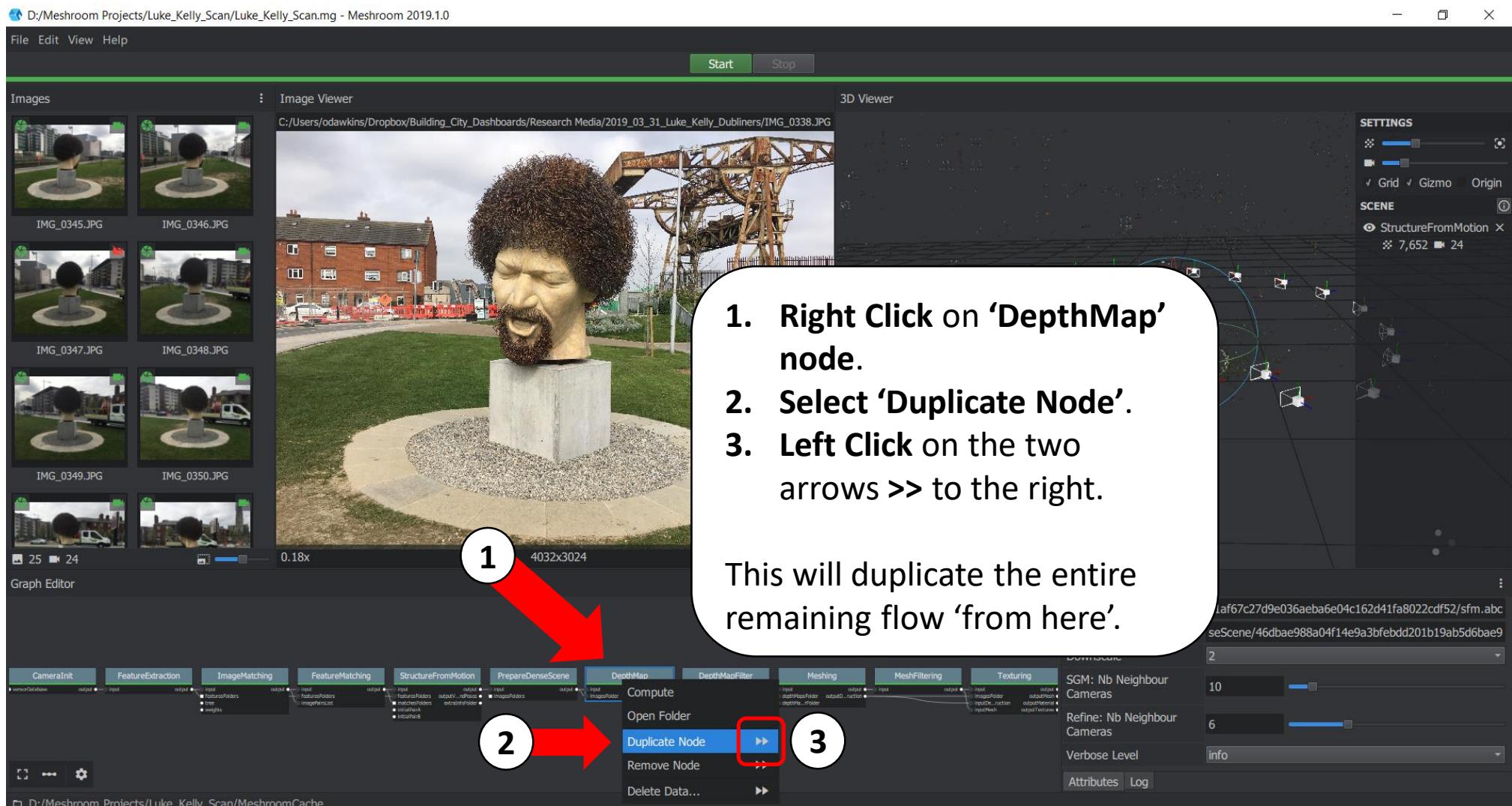


Draft Meshing via Meshroom Wiki: <https://github.com/alicevision/meshroom/wiki/Draft-Meshing>

- To improve draft meshing it is recommended that you use the HIGH preset on the FeatureExtraction node to get greater point density for the Meshing (see next slides).
- It is also possible to improve

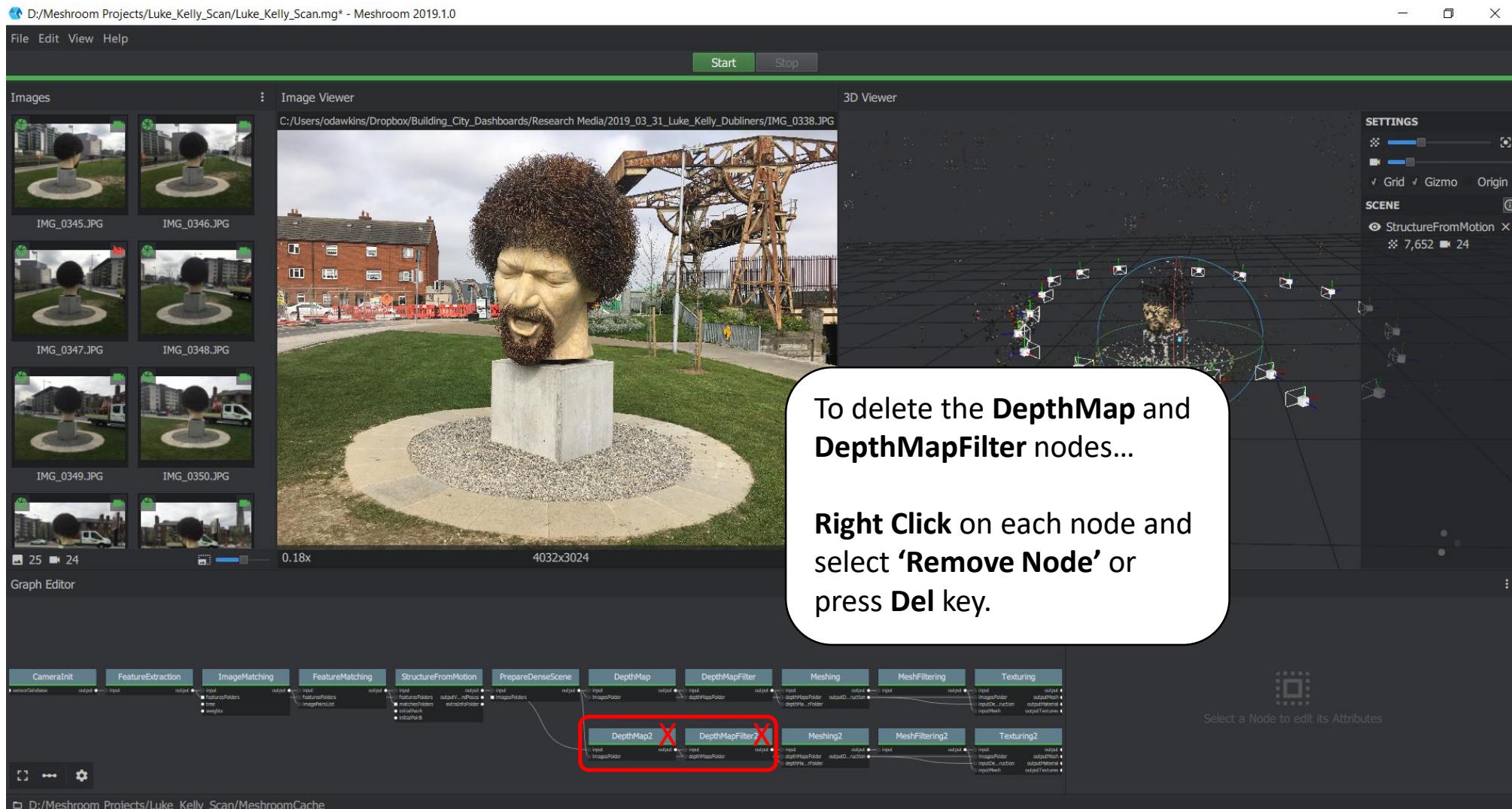


# Duplicate Nodes to create a DepthMap bypass



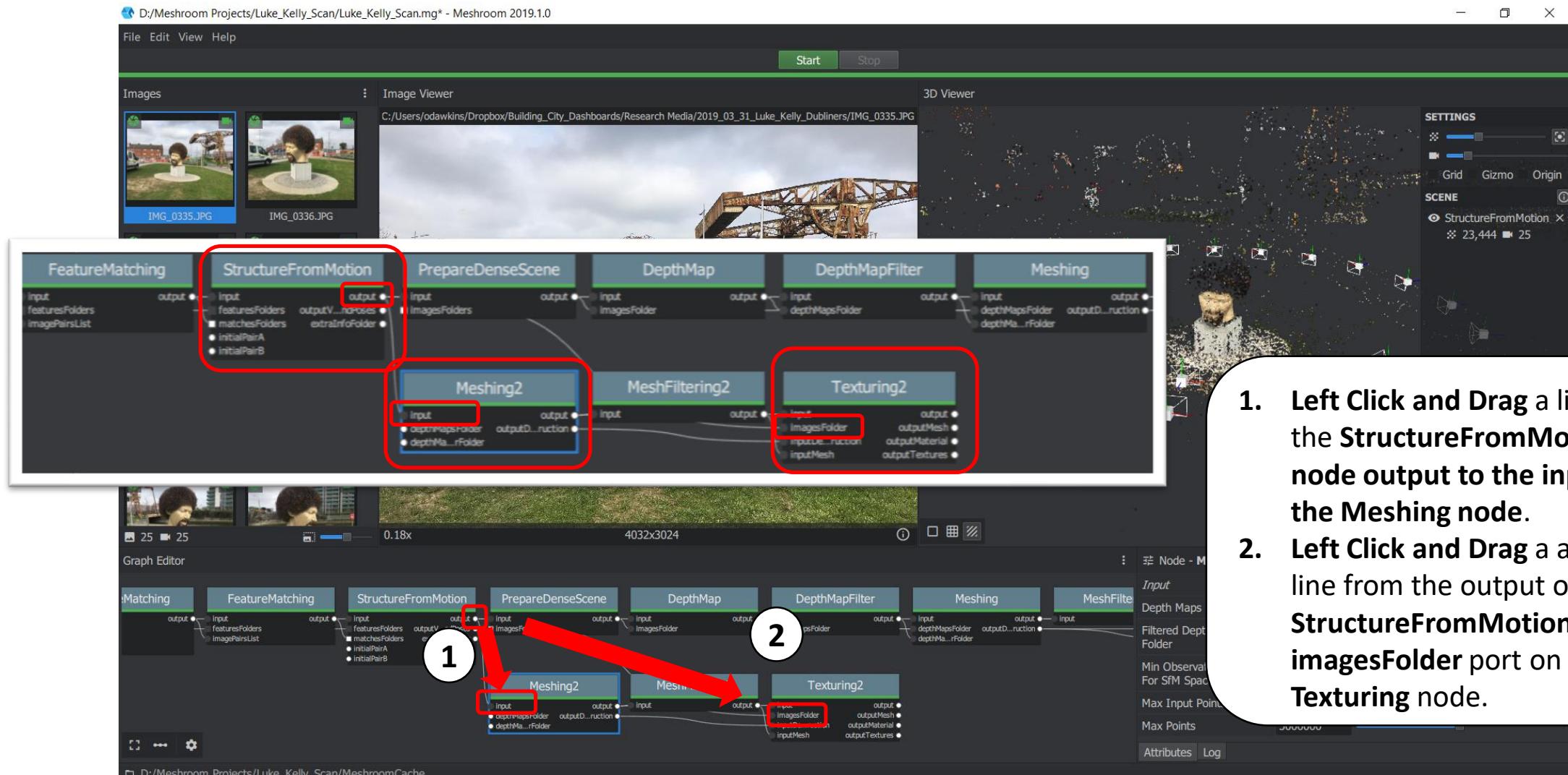


# Delete the DepthMap Nodes from your bypass





# Reconnect the Meshing and Texturing Nodes



1. **Left Click and Drag** a line from the **StructureFromMotion** node output to the input on the **Meshing** node.
2. **Left Click and Drag** a another line from the output on the **StructureFromMotion** to the **imagesFolder** port on the **Texturing** node.



# Start the CPU Processing

The screenshot shows the Meshroom software interface. On the left, the 'Graph Editor' displays a flowchart of processing nodes: Matching → FeatureMatching → StructureFromMotion → PrepareDenseScene → DepthMap → DepthMapFilter → Meshing. A red box highlights the 'Compute' option in the context menu of the Texturing2 node. The main workspace shows a 3D viewer with a bust model and an image viewer displaying multiple camera images. The right side shows the 'SCENE' tab with statistics: 23,444 points and 25 meshes.

**Right Click on the Texture Node** of your bypass and select '**Compute**'. This will run all the unprocessed nodes before it on that branch of the graph editor.

**NOTE:** Computing particular nodes can enable you to iterate and test your flow without running the whole process.



# Improving the CPU result

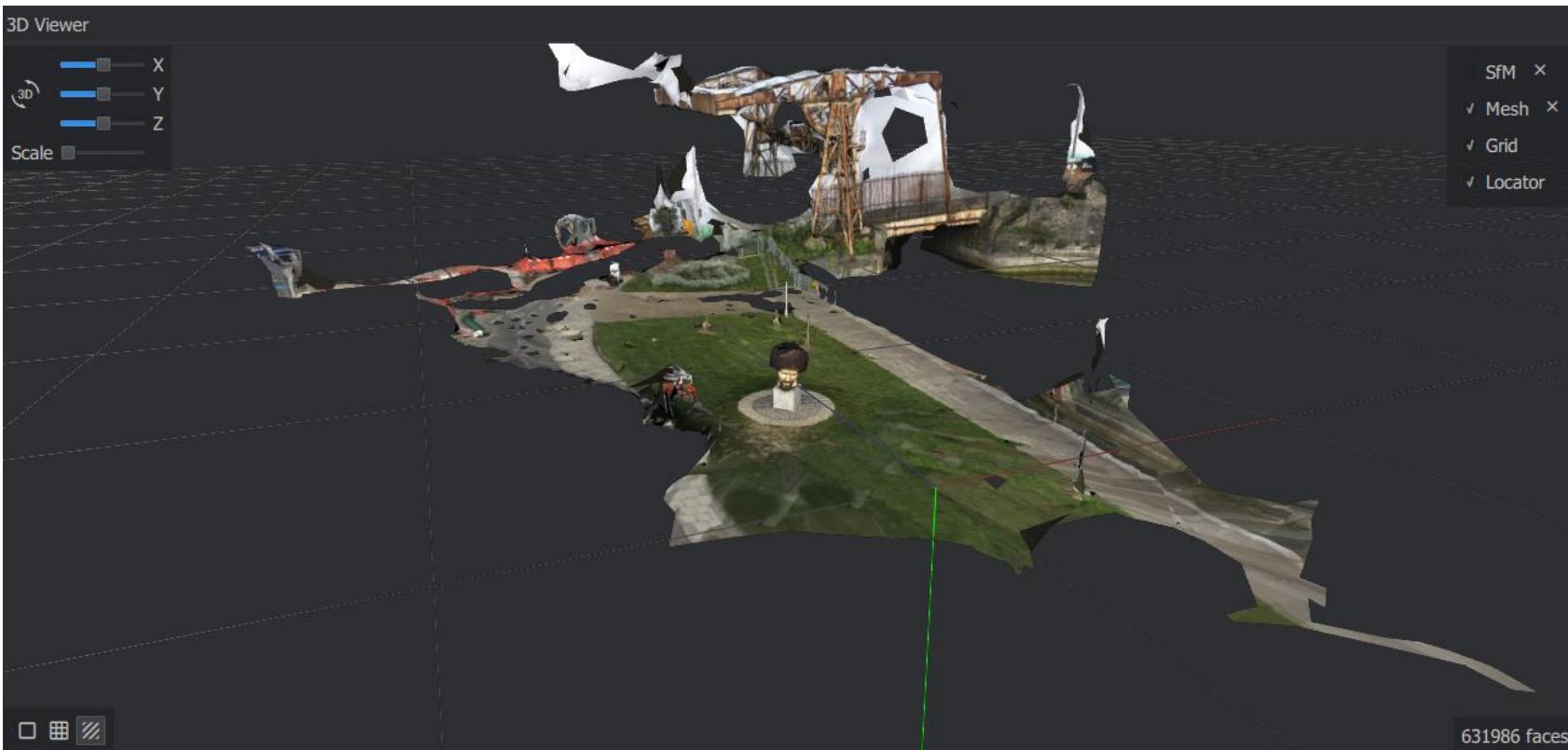
The screenshot shows the Meshroom software interface. On the left, the 'Images' panel displays several input photographs of a bust on a pedestal. The central 'Image Viewer' shows a larger view of one of the images. To the right is the '3D Viewer' showing a partial 3D reconstruction of the bust. The 'SETTINGS' and 'SCENE' panels on the right show various reconstruction parameters and statistics. A callout box highlights the 'Descriptor Types' section in the settings panel, where 'akaze' is selected. Another callout box highlights the 'Descriptor Preset' dropdown set to 'high'. Below the main interface, a text box contains the following message:

The result of CPU processing is dependent on the quality of your photos, the characteristics of your computer, and the Meshroom settings. The results can be improved by adjusting the Sparse Reconstruction parameters as outlined here:  
<https://github.com/alicevision/meshroom/wiki/Reconstruction-parameters>



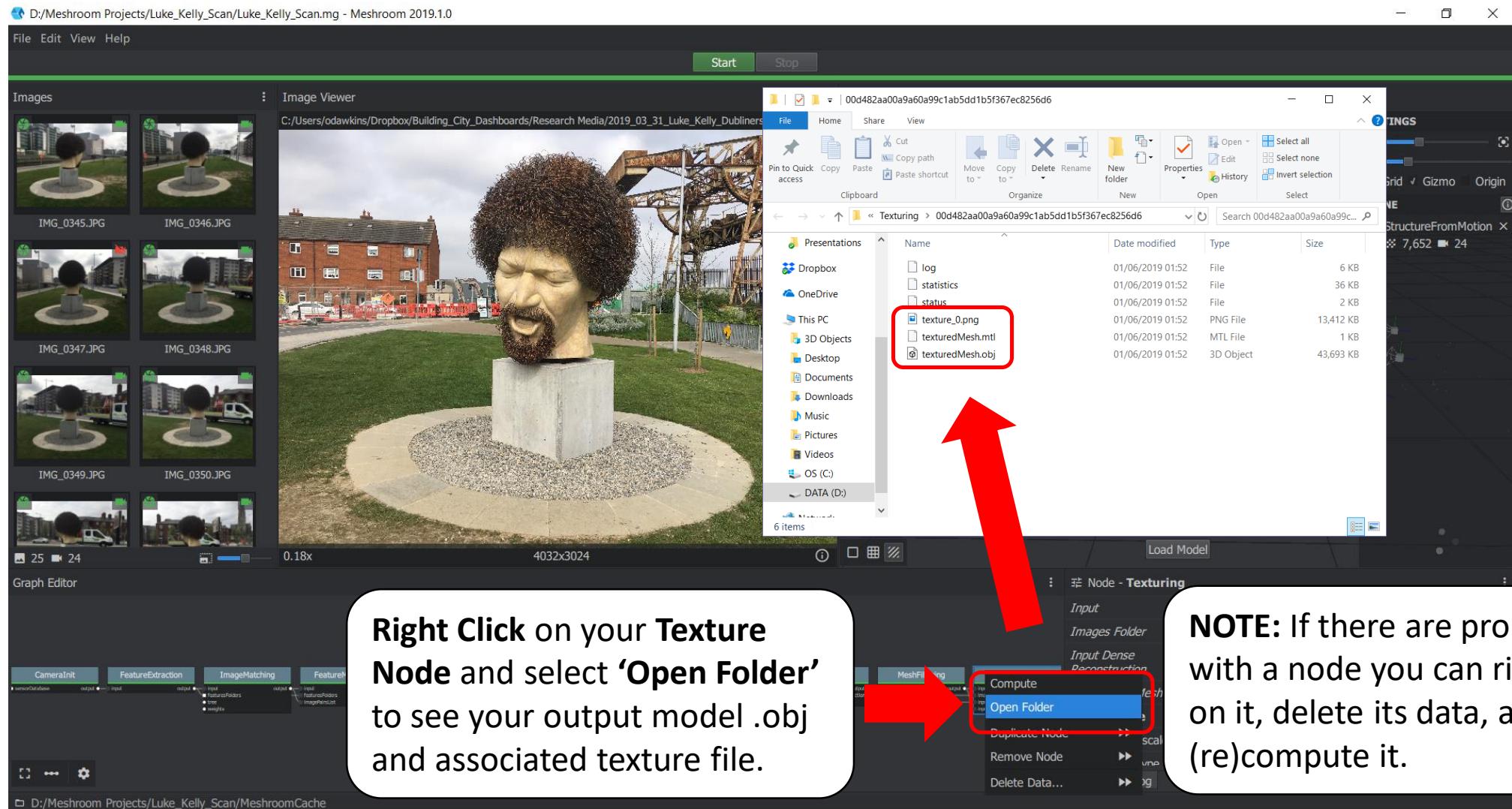
# Reviewing the result

Regardless of whether you use GPU or CPU processing, the means of reviewing the result will be the same.





# Accessing the Output Files





# Useful Links and Tutorials

- Tutorial - Meshroom for Beginners via Sketchfab:  
<https://sketchfab.com/blogs/community/tutorial-meshroom-for-beginners/> [AN EXCELLENT INTORDUCTORY ARTICLE!]
- Tutorial - How to 3D Photoscan Easy and Free! via CG Geek on YouTube:  
<https://youtu.be/k4NTf0hMjtY> [Video demonstrating a workflow from Meshroom to Sketchfab using Blender 2.7 to clean your mesh]
- Meshroom - Photogrammetry Pipeline:  
<https://alicevision.github.io/#photogrammetry>
- Meshroom Manual:  
[https://docs.google.com/document/d/17HYtYS1tvx053k3\\_nO6Z2GnP2R3cXMIGMN-1Wle3kJE/](https://docs.google.com/document/d/17HYtYS1tvx053k3_nO6Z2GnP2R3cXMIGMN-1Wle3kJE/)



# Other Free Photogrammetry Software

Software	File Formats	Operating System	Price	Comments
COLMAP	ply, vrml	Windows, macOS, Linux	Free	Not Tested
Meshroom	abc, obj	Windows, Linux	Free	Easy to install and use. <b>Requires NVIDIA CUDA GPU</b>
MicMac	geotiff, ply, xml	Windows, macOS, Linux	Free	Not Tested
Regard3D	obj, ply	Windows, macOS, Linux	Free	Not Tested
VisualSFM	ply	Windows, macOS, Linux	Free	Lower system requirements than Meshroom but difficult to install and use.
OpenMVG	-	Linux, Windows, MacOS	Free	Not Tested

Table derived from All3DP's post '16 Best Photogrammetry Software Tools in 2019 (6 are Free)': <https://all3dp.com/1/best-photogrammetry-software/>

The recommended use of a CUDA-enabled NVIDIA GPU means that Meshroom may not be suitable for all user's needs. You are welcome to consider testing the other free alternatives, or to look to popular paid alternatives (see the link underneath the table above). Wherever possible we prefer to support and use Free and Open Source Software.

For comparison with VisualSFM see 'Free Photo Scanning Workflow! (VisualSFM and Meshlab)' by Gleb Alexandrov on YouTube: <https://youtu.be/GEAbXYDzUjU>



# Building City Dashboards

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