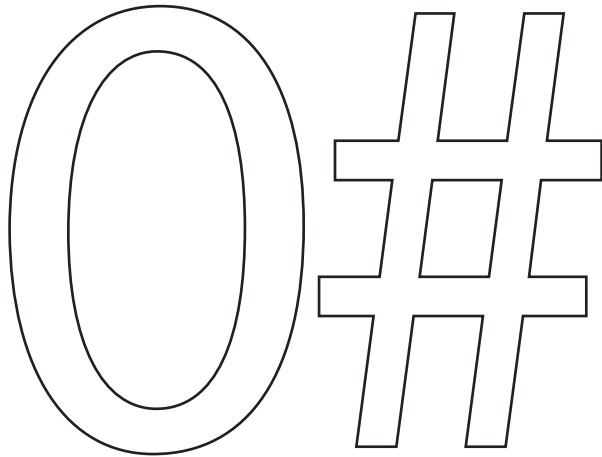


Structure from motion



Structure from motion

Kimia, Jingjing, Yufeng

Structure from motion (SfM) is a photogrammetric range imaging technique for estimating three-dimensional structures from two-dimensional image sequences that may be coupled with local motion signals. It is studied in the fields of computer vision and visual perception. In biological vision, SfM refers to the phenomenon by which humans (and other living creatures) can recover 3D structure from the projected 2D (retinal) motion field of a moving object or scene.

This technology uses 'motion parallax', which is the differences of objects movement caused by the change in the distance from the observer.

In our workflow, we can simply understand it in this way: there are thousands of different pixels of one object in the photo we take; as we change the position of camera, the pixels will change. It is these changes that help softwares like Realitycapture and Agisoft's Metashape to identify and align these picture and eventually to form a 3d model.

So why do we use it? For one thing, it is the most convenient way to transform the things in the real world into the virtual world. You can get rid of softwares to model it and texture it. Just taking photos or even filming is enough to recreate whatever you like in virtual world. Meanwhile, it also the cheapest way.

This technology is popular with cultural heritage and geosciences. Of course we can use it in any field needing 3d model. And the limitation of the accuracy is only about the resolution of your images. So better images creates better model and texture.



Image Caption

Google Earth

Google Earth has been around for about the last 10 years. And just like our Earth, it's been evolving over this time. The imagery has been getting better and better. But how is Google Earth created? How many images actually make it up? And where do they come from? It starts with looking at places that want to be collected in imagery, and then they collect it through a variety of different ways. One is satellites. Satellites create global views. And that's all 2D imagery that's wrapped around the globe. After that, they use photogrammetry to create 3D models.



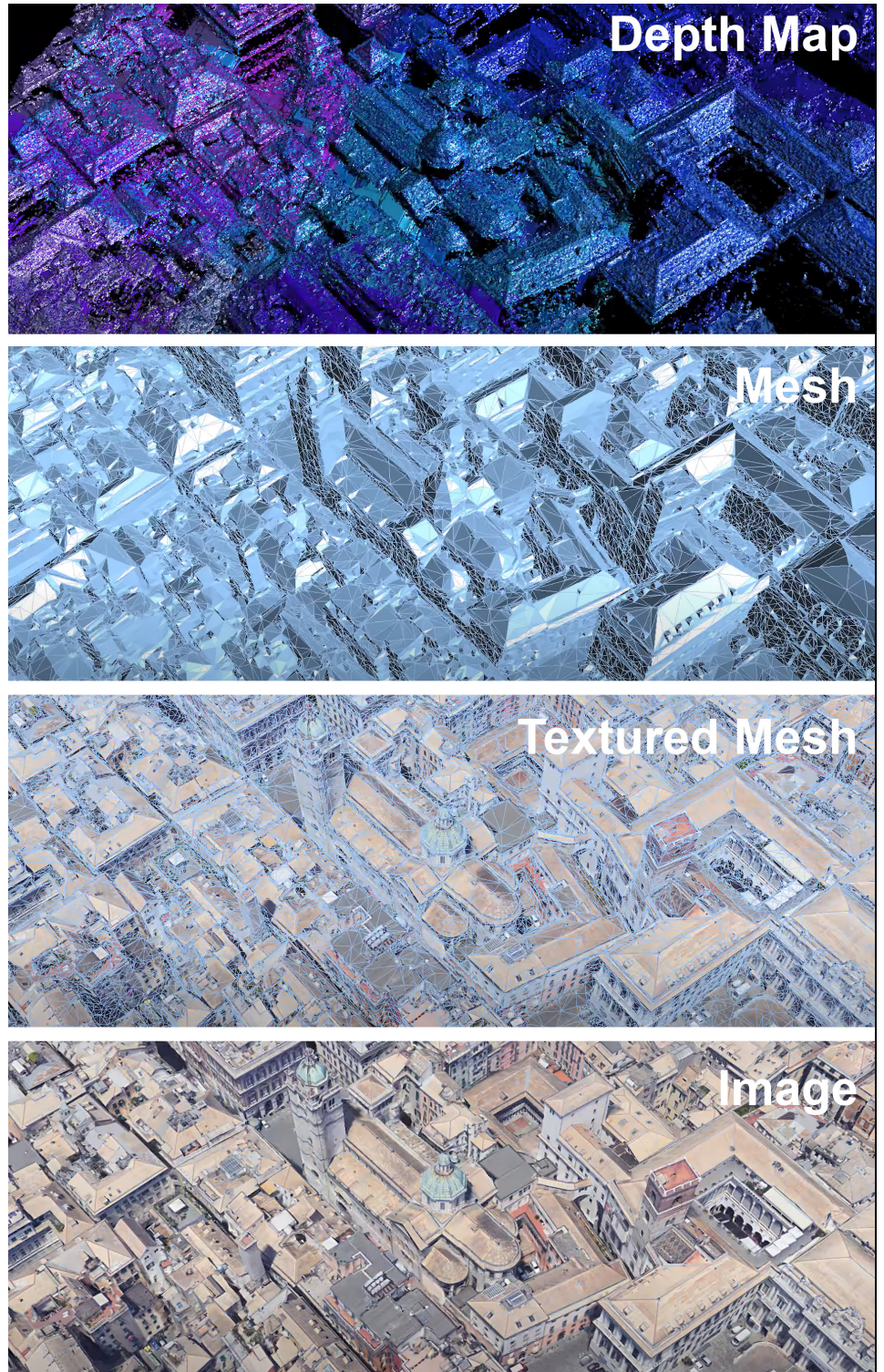


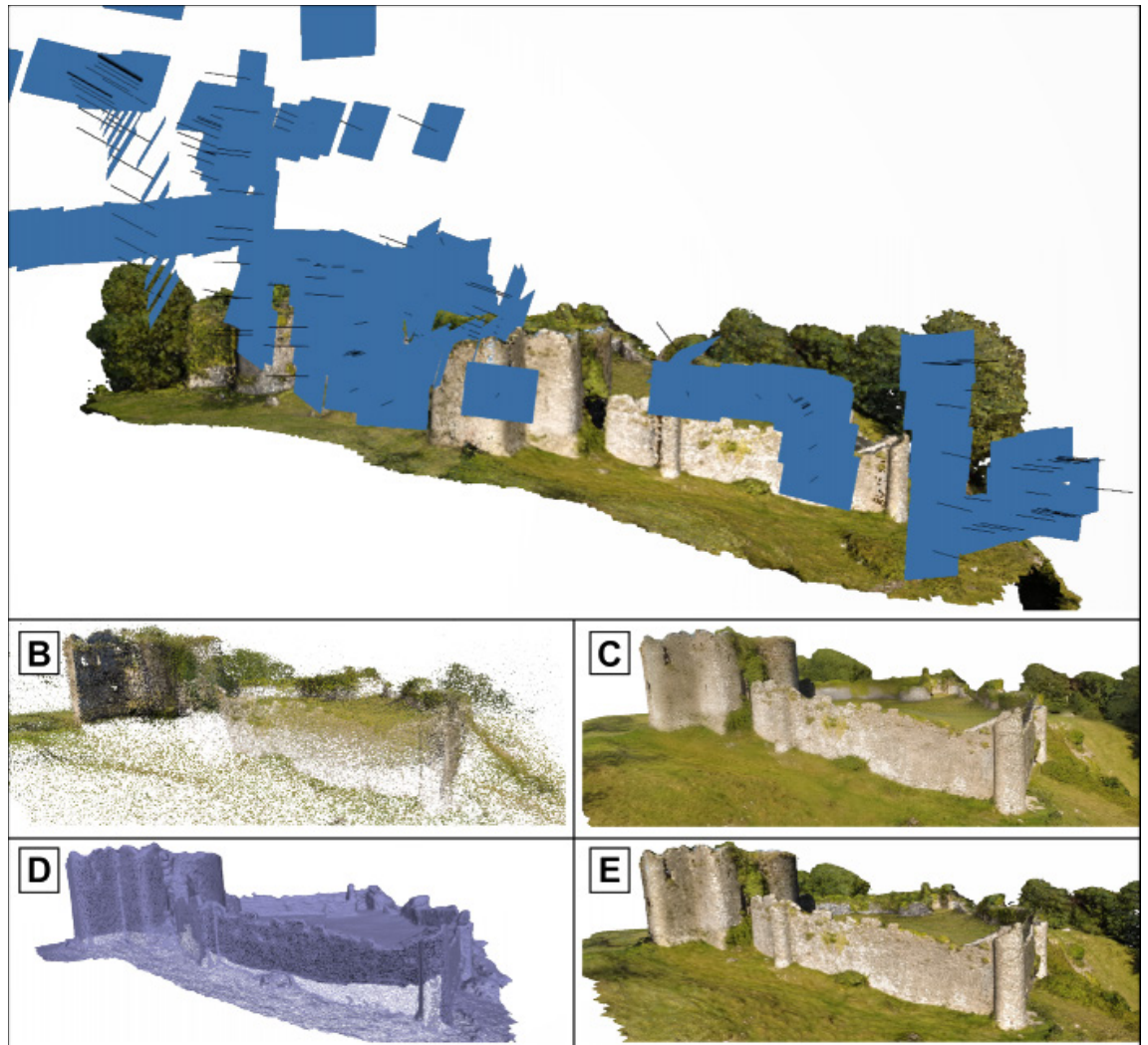
Image Reference Title (TOP, BOTTOM ETC.)
Sources (include one of these annotation boxes per image)

The process starts with looking at places that want to be collected in imagery, and then they collect it through a variety of different ways. One is satellites. Satellites create global views. And that's all 2D imagery that's wrapped around the globe. After that, they use photogrammetry to create 3D models. The computer looks for features within the overlapping images that are the same. Using a special GPS antenna that helps to identify where the camera was, they create a depth map. Then, take all of these various depth maps from the different cameras, stitch those together in a mesh, and texture it. The texture is applying the photography that we took to the sides of these 3D buildings. It's almost like taking pieces of paper and cutting them up.

Penrice Castle

Penrice Castle is the 13th-century successor to a strong ringwork to the south east, known as the Mounthybank. As drone technology becomes more accessible, it brings the possibility of using amateur footage to reconstruct heritage sites, as can be seen with this example of a Norman castle, created using imagery from an off-the-shelf system and flown by a young person. The Penrice Castle model was created in a collaboration with Mark Allan and Bradley Sparkes of Northumbria University.





Video frames and 250 higher resolution stills were processed to create a 3D model with over 12.7m points and 1.2m faces. They have been put together to create a perfectly accurate scale model of the castle, faithful to the colour and texture of the walls even down to where they are covered in ivy. The Penrice Castle model demonstrates how this approach opens up opportunities for a citizen science based approach to engaging local communities in heritage stewardship.

Whereas photomosaic processing can take lots of digital images – be they stills or frames from a video – and stitch them together, it is also possible to work out the height of objects if they were photographed from an oblique angle and not directly overhead or from the side. Adding height information gives us detail of the topography.

ANALYSIS

The cost and convenience are the reason we choose this technique rather than traditional ways. In traditional workflow, we divide this process into taking photos, modeling and texture. In our workflow, we only need to take images, modify them and leave the rest to our computers.

However, this convenience has price. Firstly, the images should be taking in a certain condition which doesn't cast shadow on objects for the shadow may interrupt the process of indentifying pictures and also will fix the light source orientation. Secondly, we should keep the lighting condition of the object same all the way of this workflow, especially don't let your body block light or cast shadow. Otherwise it will be hard for softwares to align them. Thirdly, adjust the parameters(ISO, shutter speed, aperture etc.) of your camera everytime you change position or condition. This is to get evenly lit, sharp and clear images. Finally, keep the overlap between each image over 60% and every time you rotate don't stand still but move along the surface of the object. And due to experience, rotation angle should be below 15 degree.

In the future, as the pandemic goes on, some museum can use it to hold virtual exhibition. It is also helpful for building metaverse. Meanwhile in medicine and oceanology, it can be used to record data set of thoses places like patients' skin and bottom of ocean which are hard to reach.

GLOSSARY

ISO

Conversely, when less light is available, you need a higher ISO to compensate. High ISO increases your camera's light sensitivity, which is ideal for low-light situations.

Shutter speed

It's the speed at which the shutter of the camera closes. A fast shutter speed creates a shorter exposure.

Aperture

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.

KEY TERM

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.

KEY TERM

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.

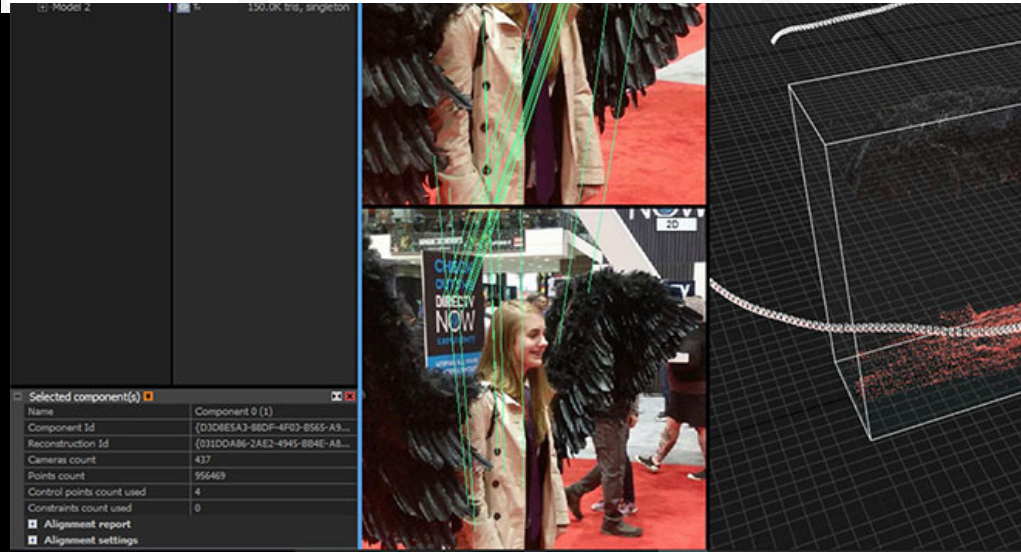
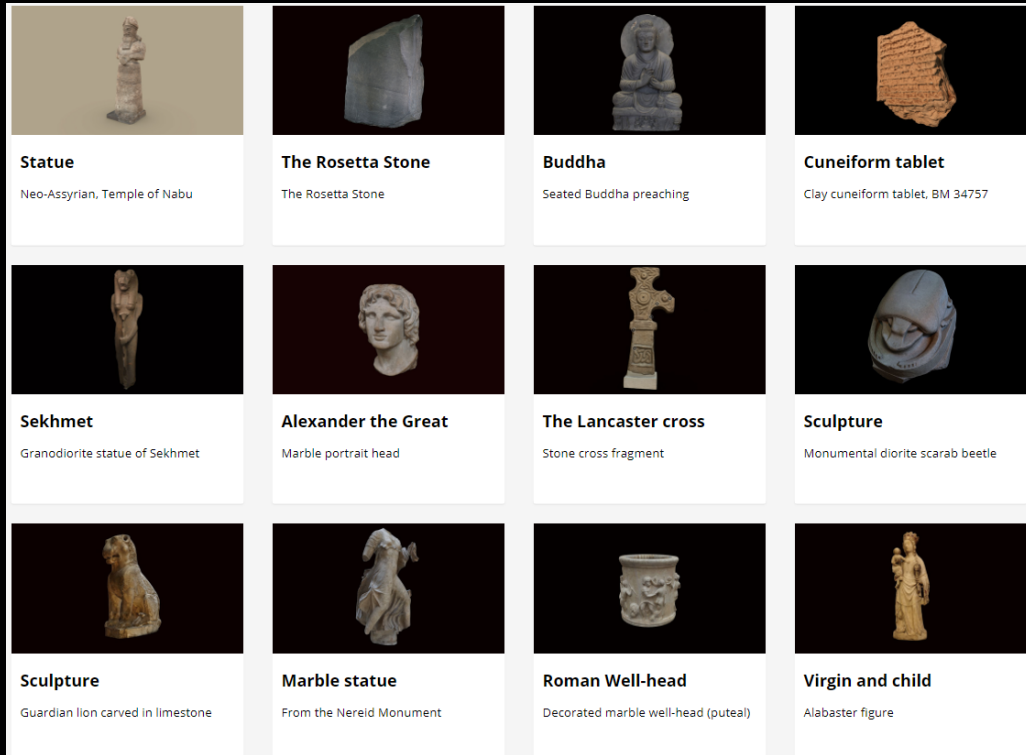


Image Reference Title (TOP, BOTTOM ETC.)
Sources (include one of these annotation boxes per image)

HARDWARE

Short description of the hardware setup you propose for IDEAS. Where do you set it up, how much space do you need, what equipment is already at IDEAS, what do users need to provide themselves? How long does it take to set up? What are some likely pressure points with the setup?

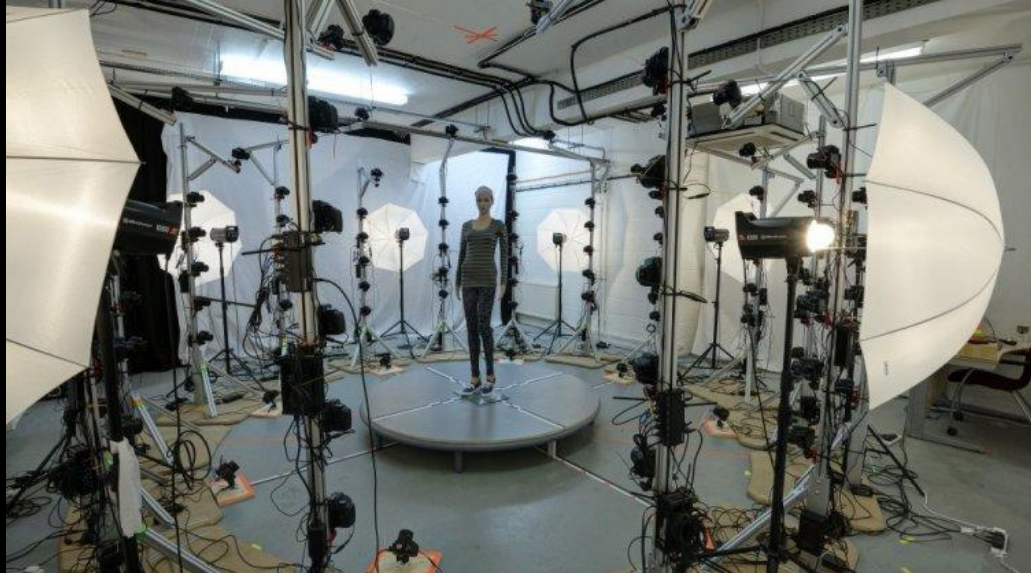
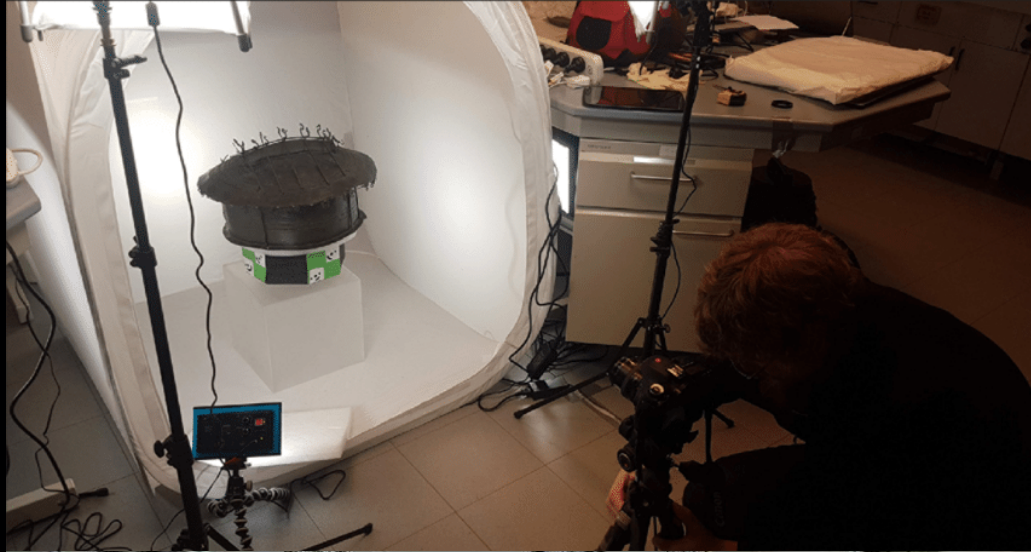
Basically you need a camera, three fill lights with tripods, a main light on top. If you take photos in an overcast day, you just need a camera. Because the rest of the list is to eliminate shadow. At IDEAS, we have 2 fill lights with enough tripods. You can use a white background as the third fill light. Just bring your phone or camera.

Setting up the workspace usually takes less than 10 min and requires a 2m*2m area as you should move around your object. For some larger items, we recommend you film them outside in an overcast day.

For your convenience, you can bring a turnplate so you don't have to move around which is very tiring.

LIST OF REQUIRED HARDWARE

- A camera (or your iphone)
- Three fill lights (with tripods)
- A main light (usually on top)
- Something as the background (optional, like a waste paper)
- A turnplate (optional)
- A computer intalled with Realitycapture



Caption

SOFTWARE

Short description of the software setup you propose for IDEAS. How is this maintained on the Lab computers, or do students use their own machines? Where can the software be downloaded from? How to install, if there are educational licenses, what steps are required to install? If it is a plugin, how do you enable it? How does each software connect to others?

LIST OF REQUIRED SOFTWARE

Lightroom	Classic or latest
Photoshop	2021 or newer
Realitycapture	1.2
Meshroom	2021.1.0 64-bit



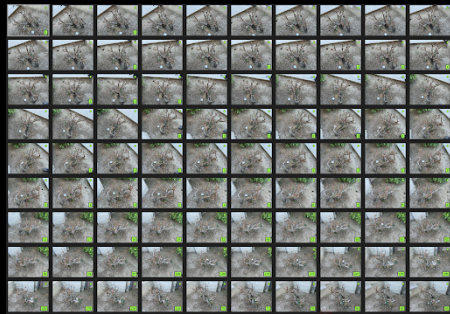
1.Set the object in a no shadow condition

For exterior, it can be a overcast weather or some shade in a sunny day.
For interior, it better is 3 fill lights and 1 main light to eliminate shadow.



2.Plan your camera track to cover the object

Usually, three different height is enough. But to scan some details like holes or gap, it is always recommended to have more images on those parts.



3.Take a great number of photos

Usually, the angle between each position should remain in 15 degree. For horizontal movement, at least 60% percent overlap between each picture should be guaranteed.



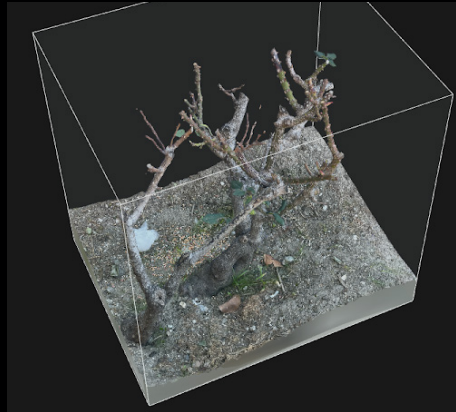
4.Put photos into Lightroom (or PS) to make them flat

To reduce shadow and high lightbetween each picture should be guaranteed.



5.Put your photos into Realitycapture

Usually, the angle between each position should remain in 15 degree. For horizontal movement, at least 60% percent overlap between each picture should be guaranteed.



6.Congratulations on your first success!



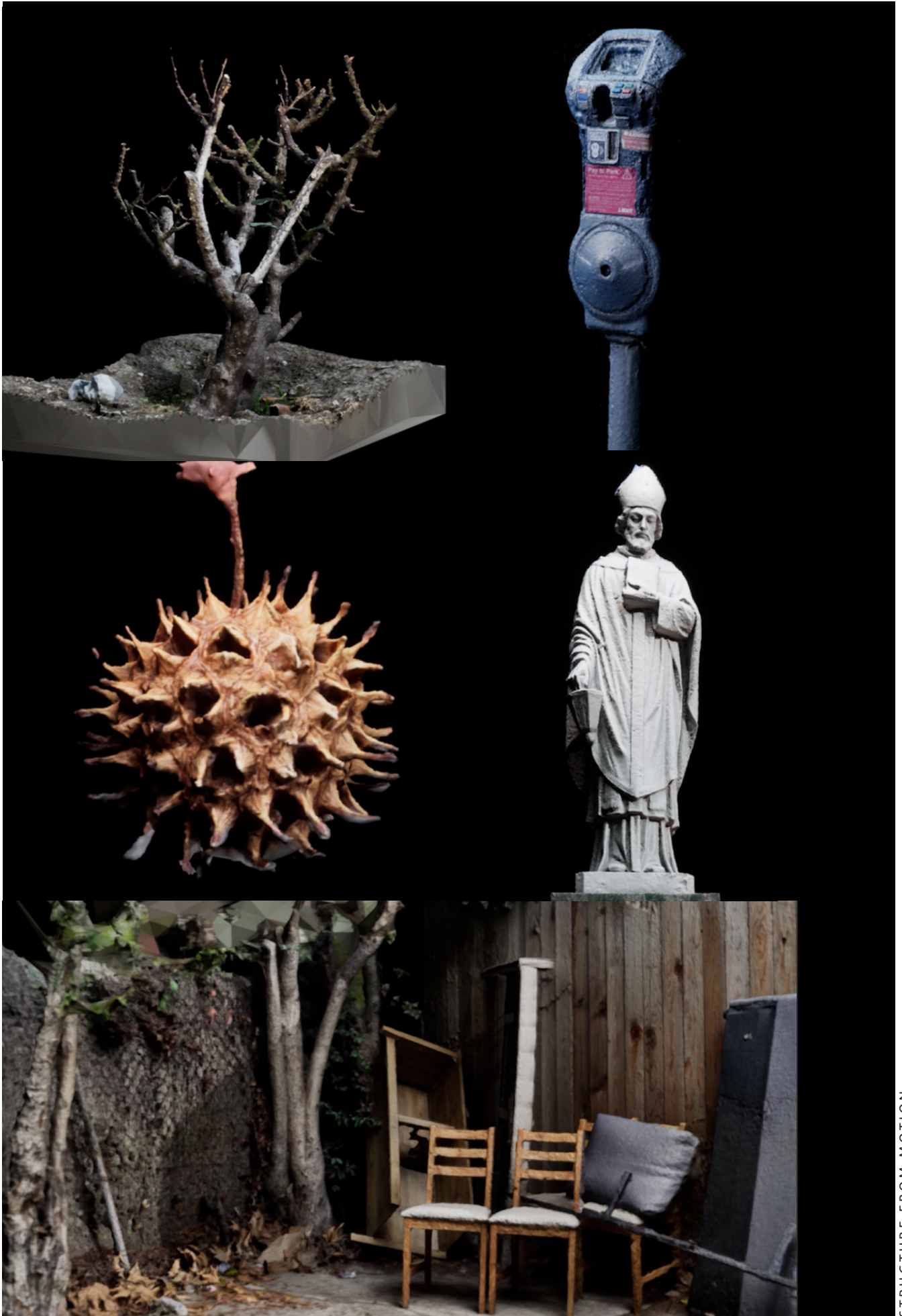
KIMIA MOHAMMADI, YUFENG LUO, JINGJING FANG



DEMOTITLE

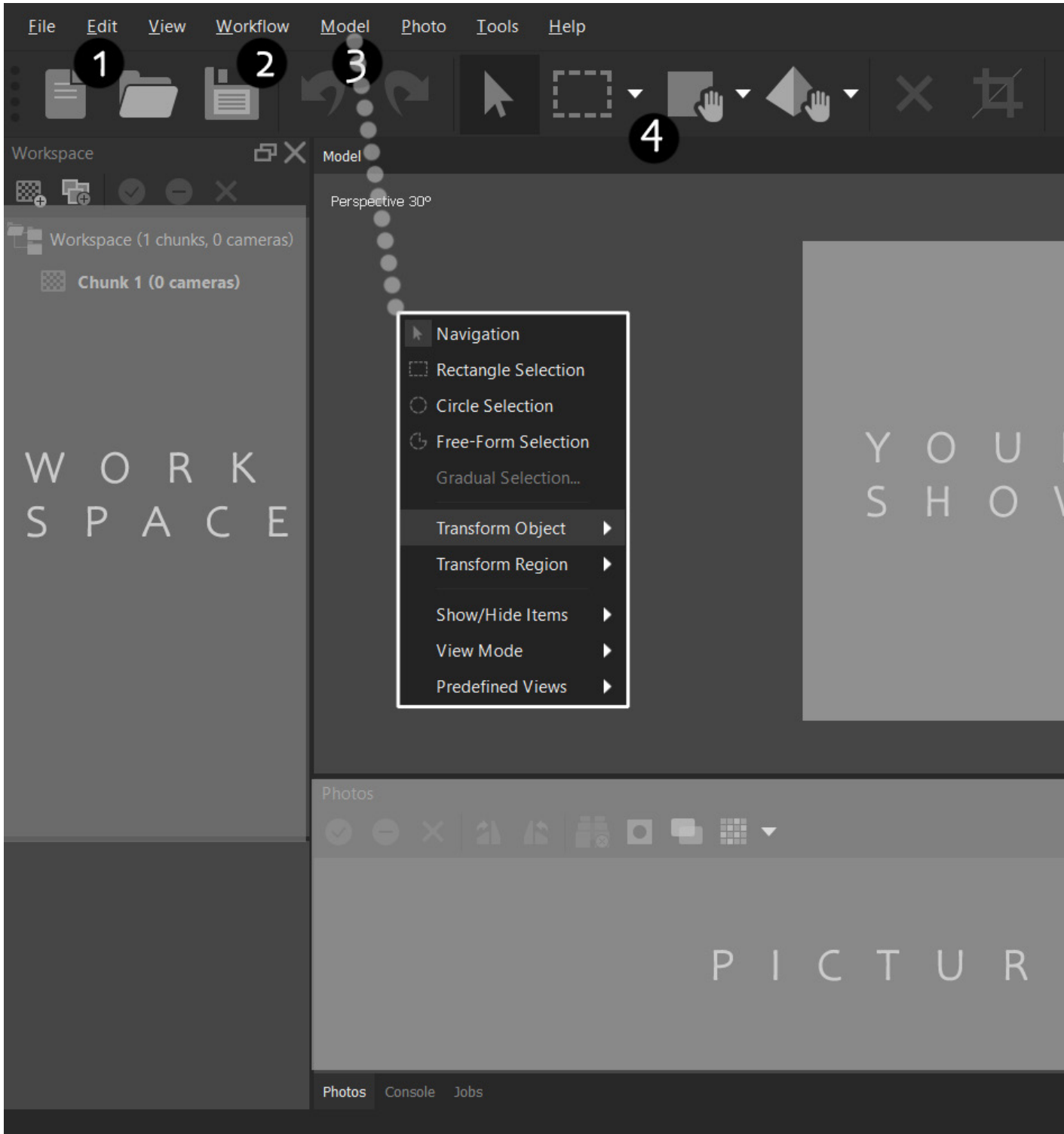
Our demo vedio includes some of the best results we get with photogrammetry, which are a statue, a bush, a church facade, a fruit and a corner of street. These items cover from smal objects to large objects with different levels of details.





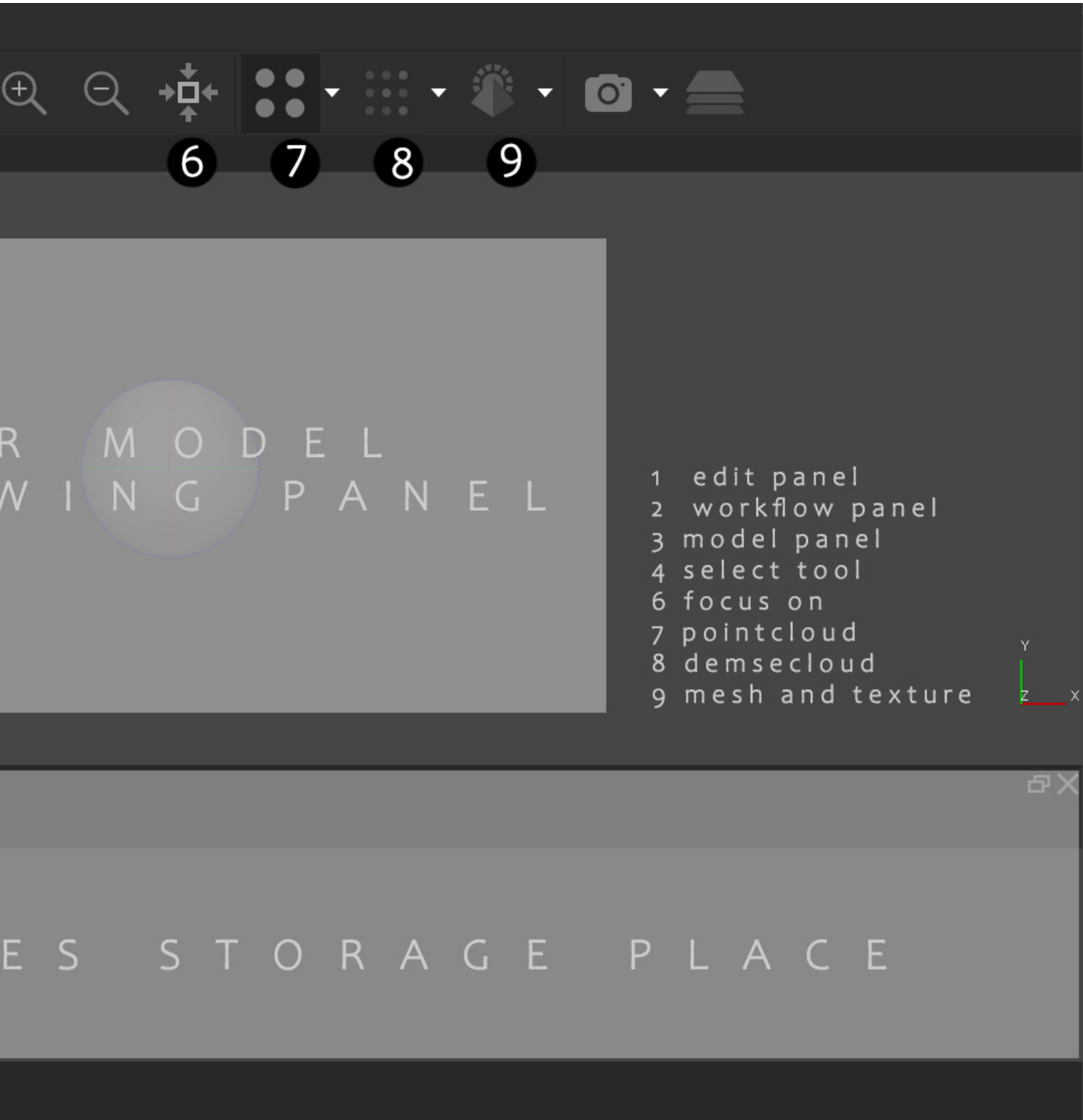
Caption

PHOTOGRAMMETRY PROCESSING



00 SMALL OBJECTS

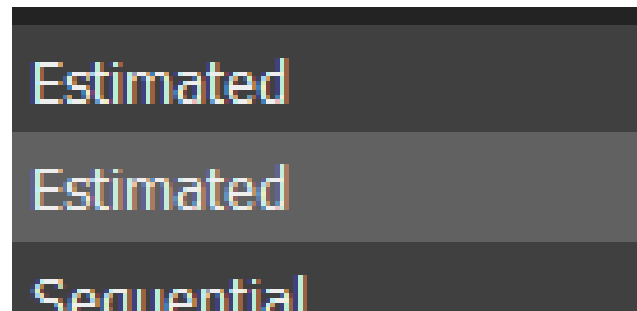
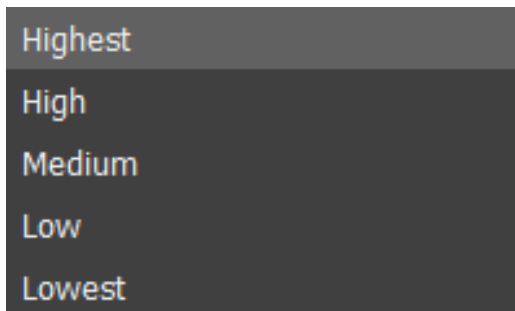
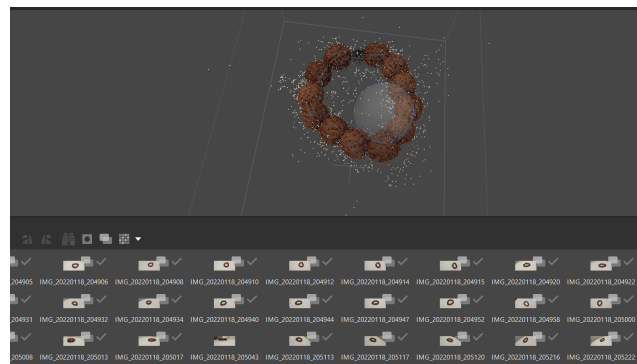
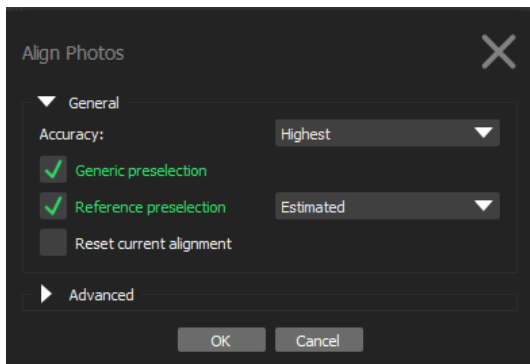
METASHAPE_Manipulating interface introduction



01 choose clean monochrome environment, with lights above and almost around the object. Then use camera devices to take pictures for about 50-100 pics. Then open Metashape. Then uploaded them into the pictures storage place of the software [dragging them from files]

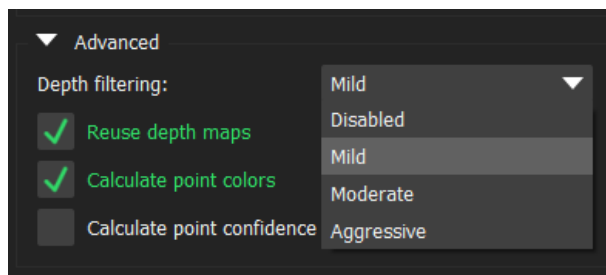
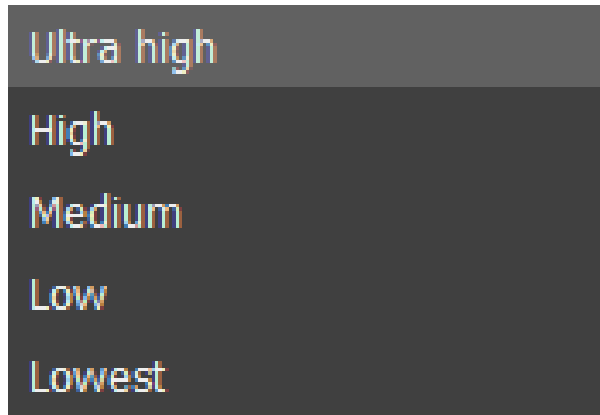
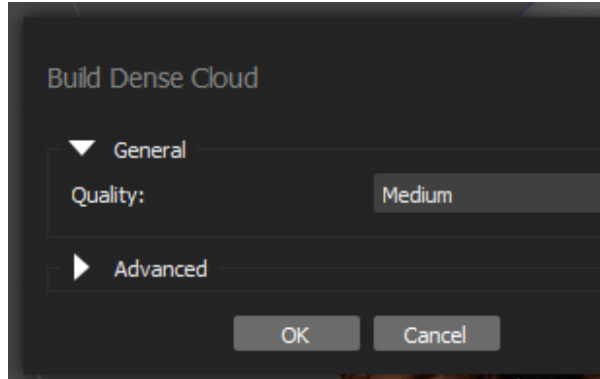


02 After uploading all photos you take, use “align photos” in workflow panel to analyze the photos into pointcloud models. [ZEDIT PANEL ---workflow---align phots] and choose accuracy range depending on your electronic device quaility. There are 5 accuracies at all, it you want to take more than 1 hours ,choose highest. if you want to do it in few mintes, choose medium and below. Also make sure it is estimated instead of sequential.



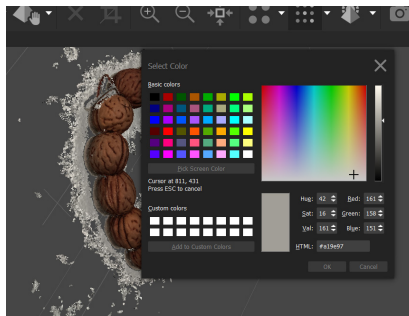
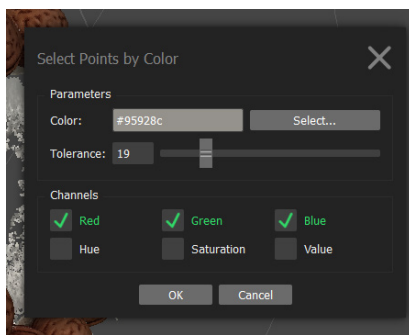
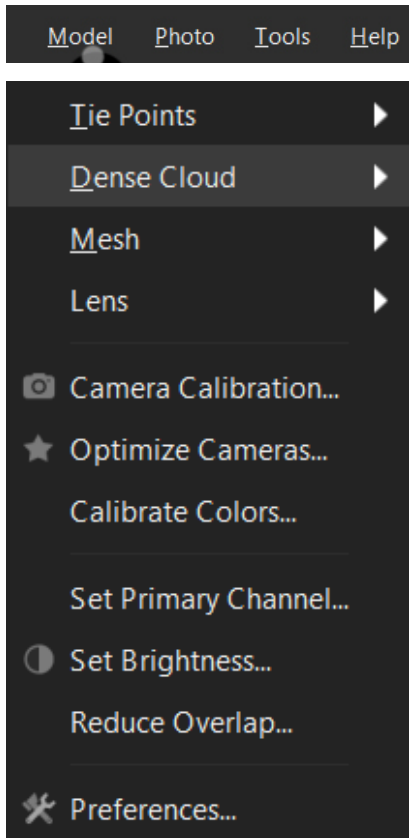
03

build cloud points [2EDIT PANEL--workflow--dense cloud] and choose the quality depending on your electronic device quality. Here are 5 qualities at all, if you want to take more than 1 hours, choose ULTRA HIGH. if you want to do it in few minutes, choose MEDIUM and below. Make sure depth filtering is mild.



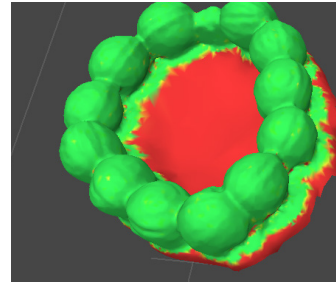
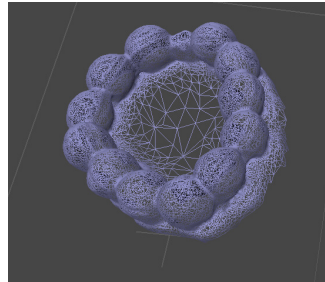
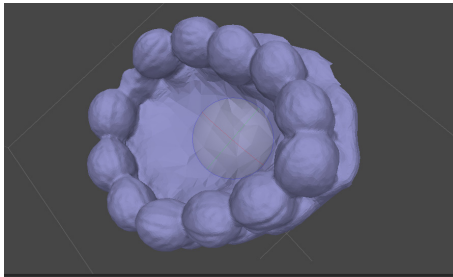
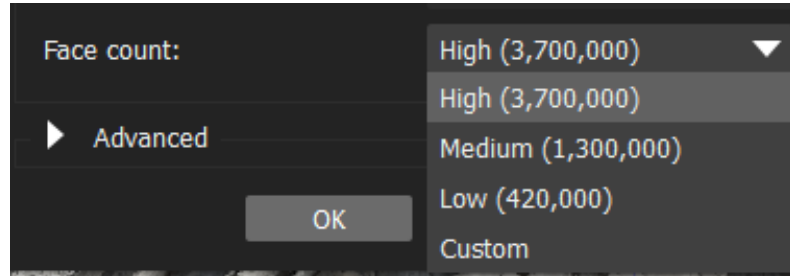
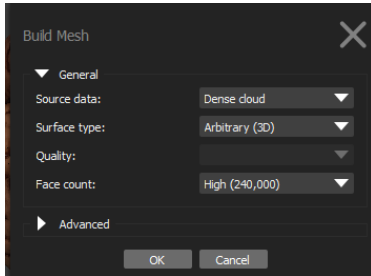
04

In the process, click the tools in the top panel, and click DENSE CLOUD, and select points by clour ,choose the background clour and delete the unusful environmental points. keep the mind that it only works when your objects and the background have different colors.



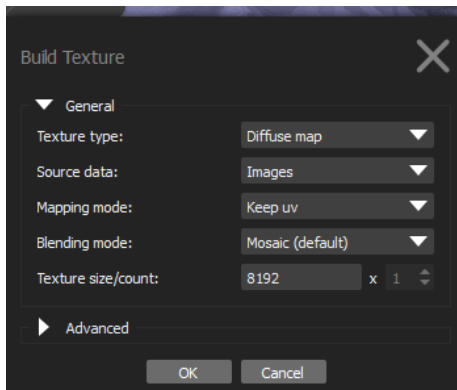
05

use the dense cloud data to build mesh [2 EDIT PANEL-- workflow---build mesh ---general---source data---dense cloud] and choose the face count depending on your own devices.Here are 4 qualities at all, if you want to take more than 1 hours ,choose HIGH. if you want to do it in few mintes, choose LOW. Or you can let your device choose it for you, which is Custom.



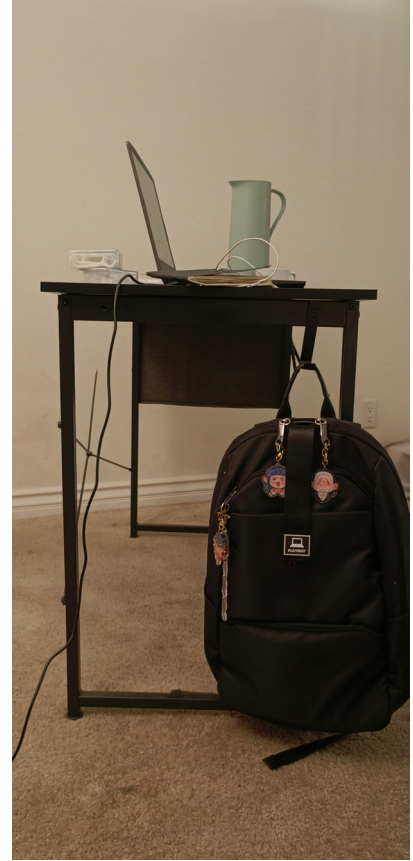
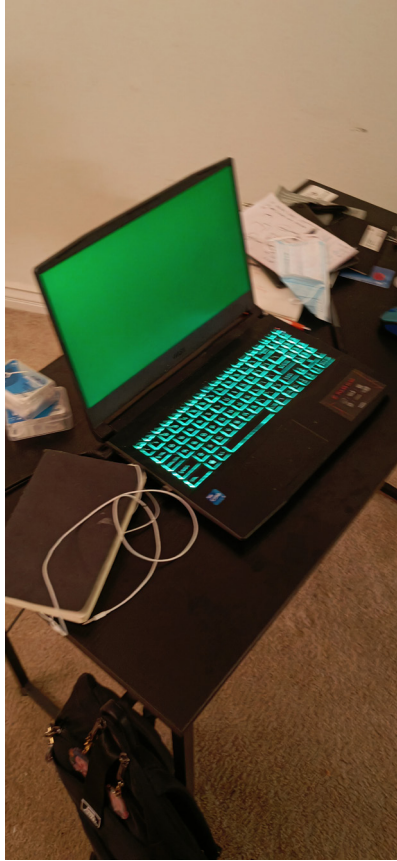
06

Build textures [2 EDIT PANEL-workflow-build Textures]to get the final models,don't change any settings. Also you can choose the different small logos beyond the EDIT PANEL[6,7,8,9] to see the previous status, and rotate objects.



INTERIORS

METASHAPE_Manipulating interface introduction



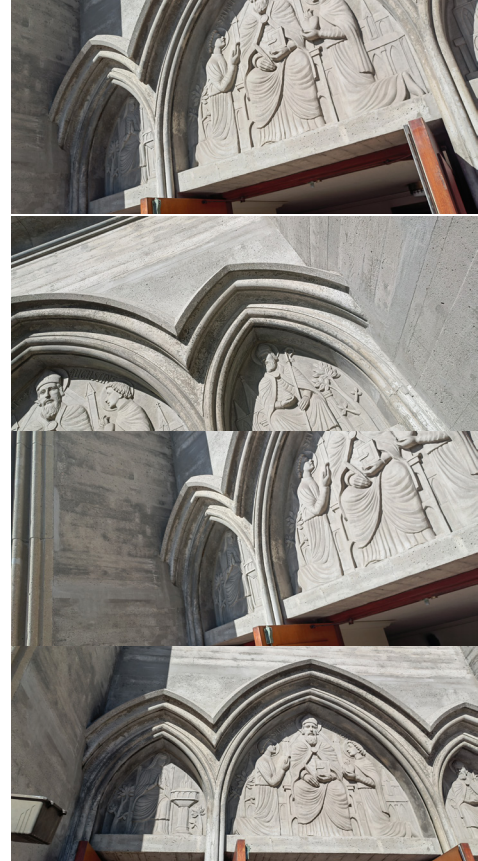
PHOTOS: Taking good photos is the most important part in interior photogrammetry. And when you are larging scale of the objects you are taking cameras, the number of the photos required increase, Like this table and the corner of my room is quite big, it takes 100-200photos to capture a space in 1 m².

The other point is choosing angles of your interior thins. you can taking photos around it again and agin. Each time you walk around it you can change a little of alltitude. So after turning 3-4 circles, you will get 200 pictures of different angles. Do not forget to take photos below your heights.

LIGHT: choose a stable, bright environmental light, I use my floor lamp which is not bright enough. So keep 2-3 lamps if you want to use flour lamp in low luminace.

EXTERIORS

METASHAPE_Manipulating interface introduction



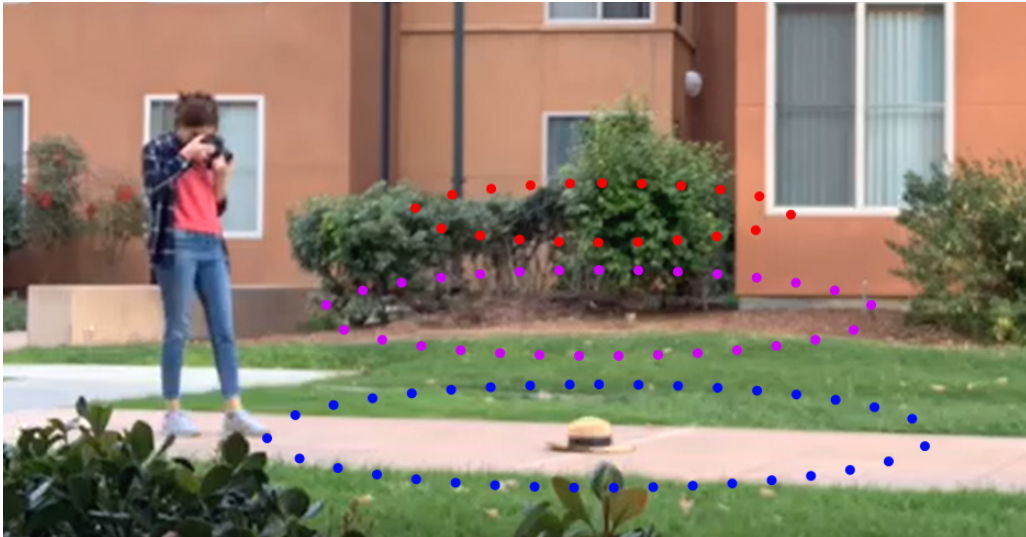
PHOTOS: Taking good photos is the most important part in exterior photogrammetry. And exterior photogrammetry at least need 200 pics to get a well result. Sometimes it is hard to capture the upper part of the thing you want. At that case, bring a portable chair or let your partner holding you high. This exterior part is contributed by a chair borrowed from the church.

As the angles you can have is limit when you capturing exterior things, you should be more careful when you choosing the object. You should make sure you got permission for thaking photos of it and also there is not so easy to be blocking by the passengers.

LIGHT: choose daytime with good weather, not sunny but with a little cloudy will work. Sunny days will creat a bad effect on the photos such as deep shadows. DO NOT choosing night time or evening time, the lighting sources are terrible then.

Tomorrow, Mar 3			20°C / 12°C
Fri, Mar 4			15°C / 9°C
Sat, Mar 5			15°C / 6°C
Sun, Mar 6			16°C / 5°C
Mon, Mar 7			19°C / 7°C
Tue, Mar 8			22°C / 8°C

Small objects photography



First things first, you need to capture a clear and well-exposed series of images of your object. This include moving around the object step by step and capturing it from different angles. After you are done with one side You can flip over your object to take photos of its backside. Remember that the images be better to slightly overlap each other. Avoid any harsh light or shadow on your object. The best weather condition for taking photos is a partly cloudy day. Choose a white area, with enough lighting and no pointed light or any reflection.



Image capture setup

iPhone:

Focus: Auto

ISO: Within the 100-200.

Aperture: In most cases, an aperture between f/9-13 will work best.

Shutter speed: 1/160 or higher.

DSLR camera:

Focus: Auto

ISO: Within the 100-200.

Set your white balance.

Aperture: a low f/stop around f8 to f11.

Shutter speed: If you are working in aperture priority (A or AV) mode skip this step! The camera will adjust the shutter speed accordingly. Most likely, you'll be setting your camera to a 1/80 shutter speed or higher depending on the light quality.



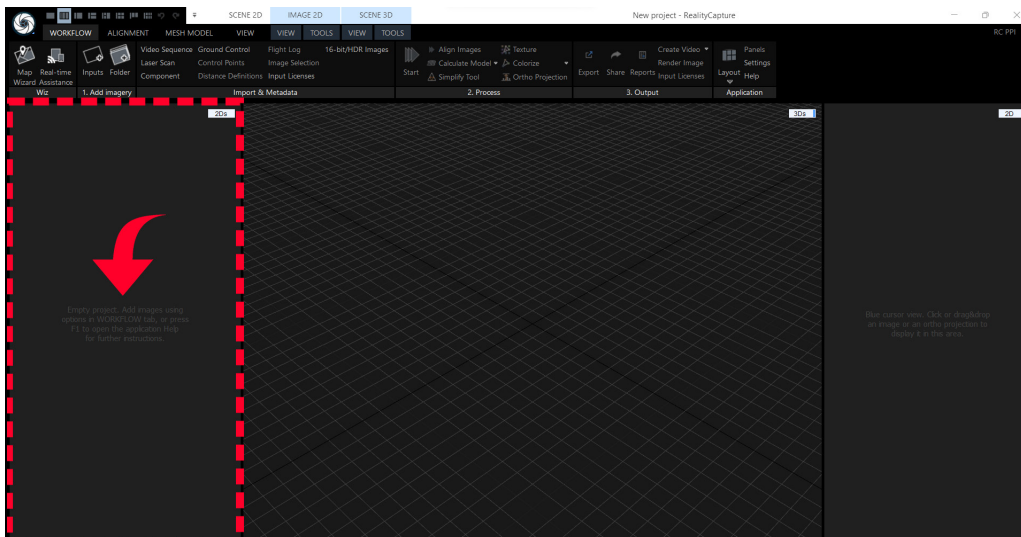
01

After capturing the images, you need to import them into the computer to create the digital model of your object.



02

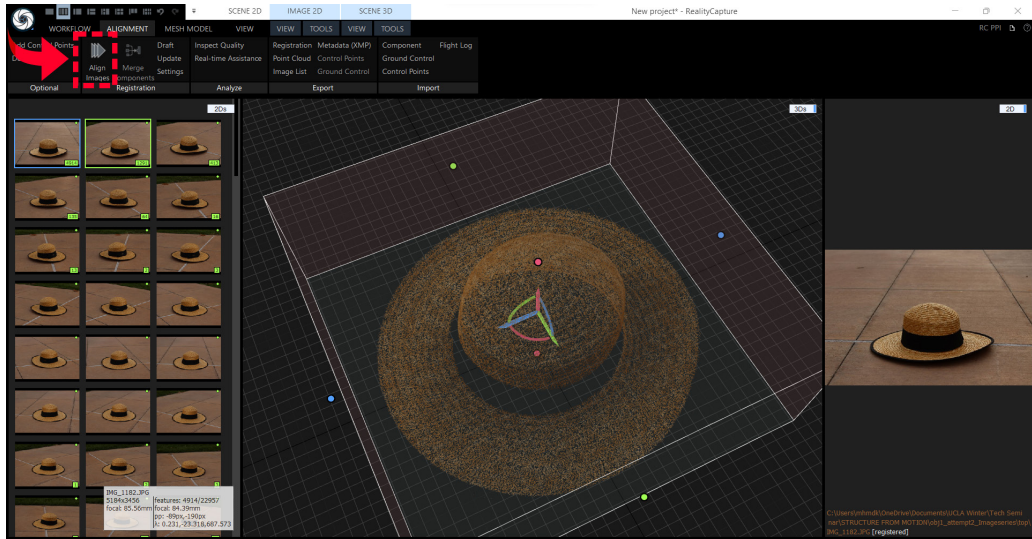
Now, you can import the images into Reality Capture:
 1. Open Reality Capture.
 2. Select all the images and drag and drop them to the left box like in the picture below.





03

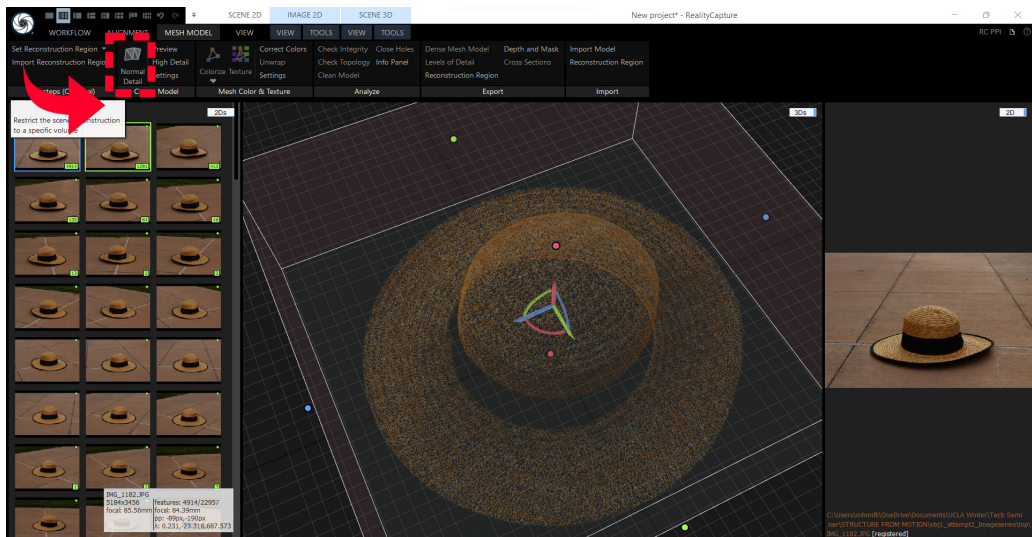
In the next step, you align the images:
Under the ALIGNMENT tab, click on "Align Images" button. This may take a few minutes depending on the number and the quality of the images.



04

Now, you have your point clouds. You need to make mesh points. On the MESH MODEL tab, click on the "normal detail" button. This may also take some time. So, be patient.

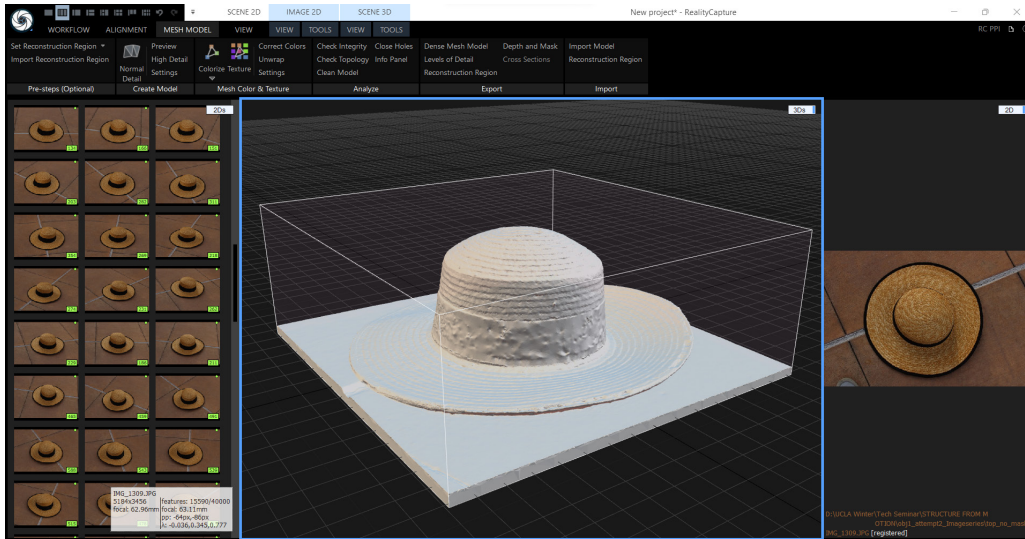
(If you do not see the point clouds, it means you do not have enough overlapping images. In this case, you need to capture the images from scratch).





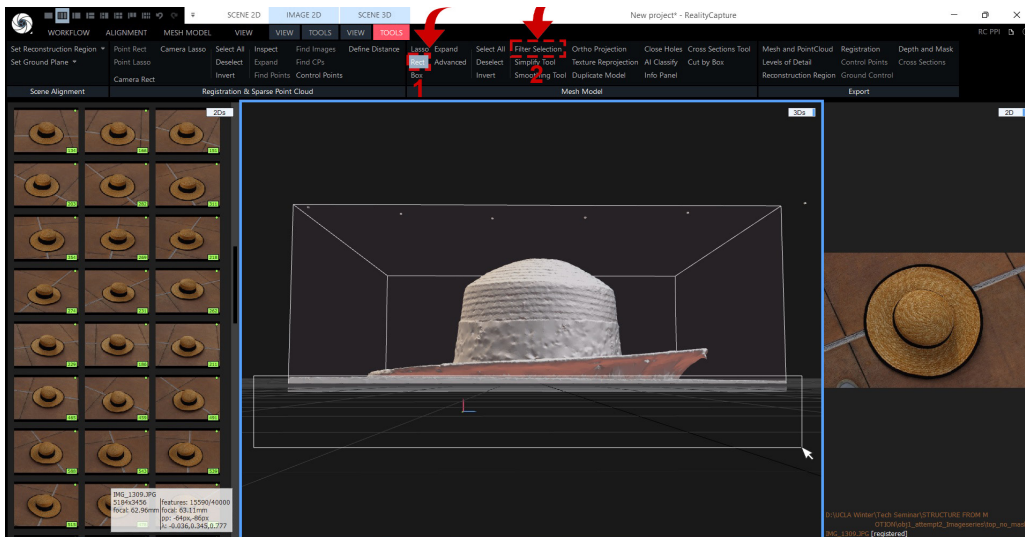
05

Here you have your mesh. But you do not need the ground mesh. To delete that, first go the front view.
(left click: Pan, right click: rotate)



06

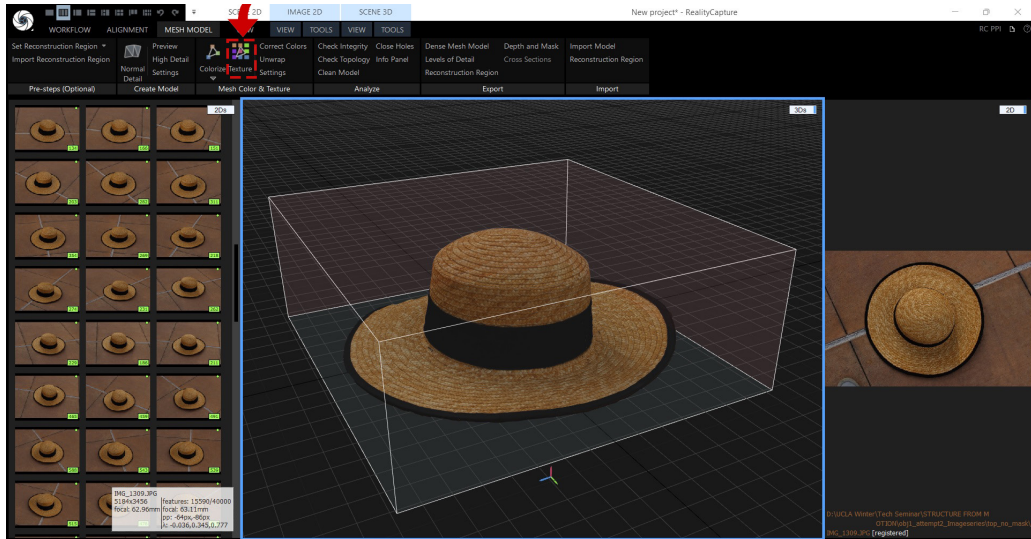
Go to the TOOLS tab, and select "Rect" (rectangular selection). Select the part you want to delete. Then, click on the "Filter Selection".






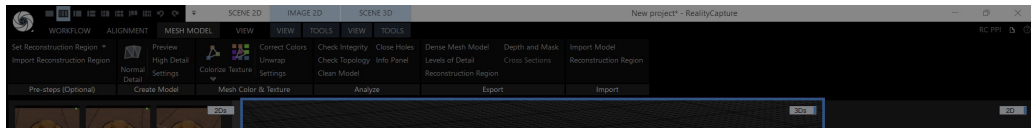
07

It is time to put the texture. Go back to the MESH MODEL tab. Click on the "Texture" button. This may take some time, as well.



###

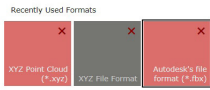
You have a 3d model of your object. Now, you can export it as an obj/ fbx file: Click on the  icon on the top left corner > export. Choose the format and export.



Export Your Creation

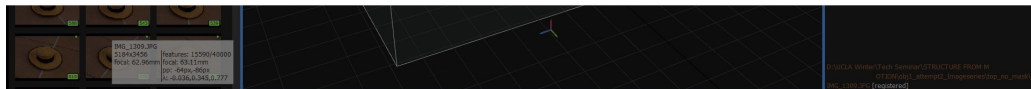
Select a desired export format.

Filter



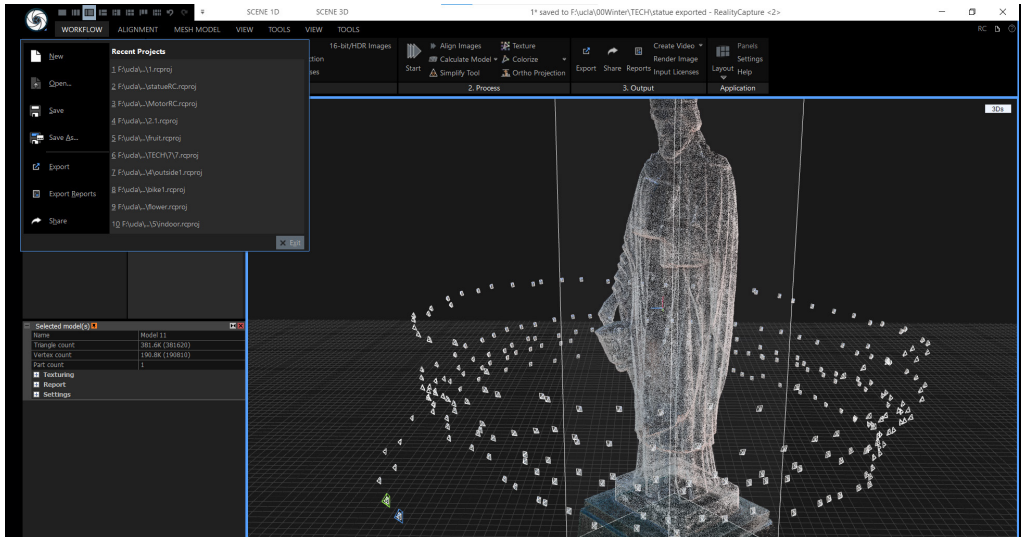
Show feasible options only

Cancel

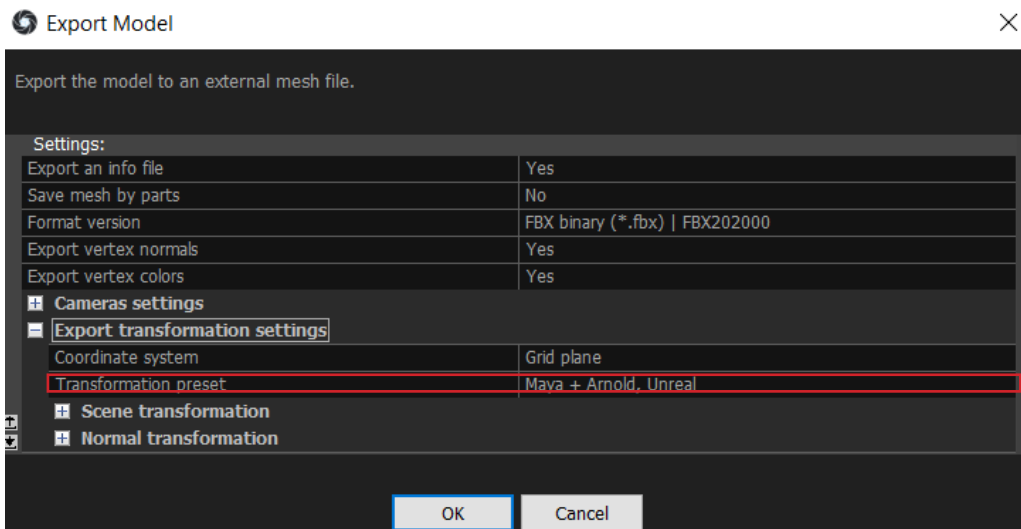


1 HOW TO EXPORT

When you finish your model in Realitycapture, press the circle button on the left corner, then choose 'export'.



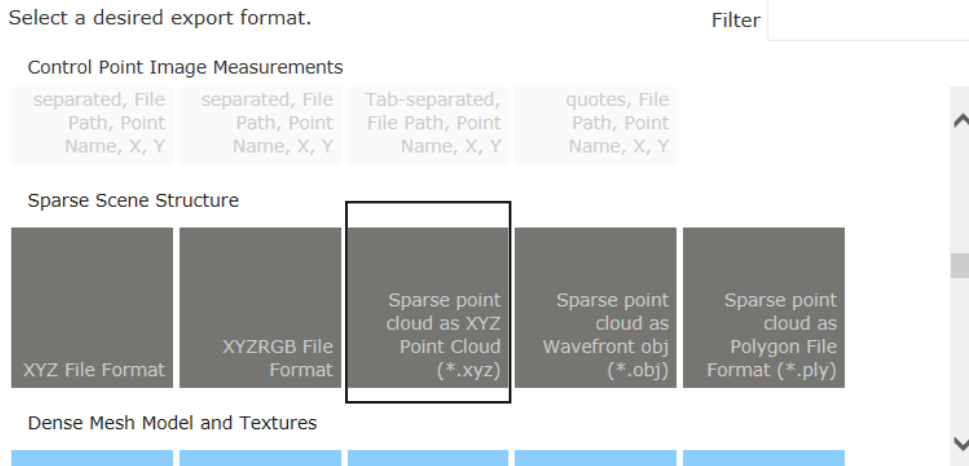
3 After you click your format option, you choose where you want to export and get this chart below. Choose the software you want to put it in in 'Transformation preset'. For the rest, just make it same as it shown below.



2

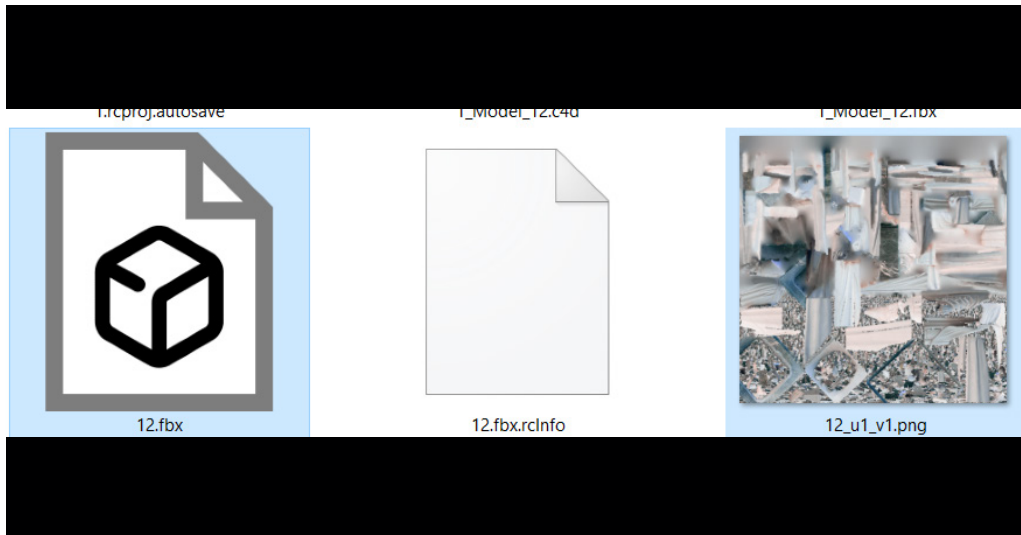
After clicking 'export', you can put the format you want in 'filter', or just scroll down to find it. If you want to export into C4D or Unreal engine, fbx would be the best choice. If you want point cloud in Unreal engine, you may choose 'Sparse point cloud as XYZ point cloud'

Export Your Creation



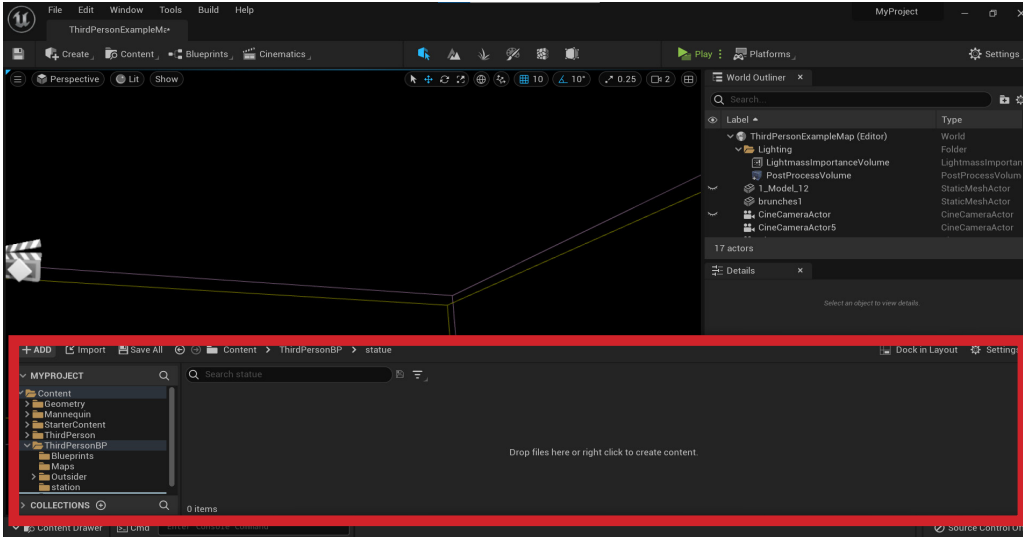
4

When finishing exporting, you will get a fbx. model and a texture picture. If you choose to export point cloud, you can only get one file.

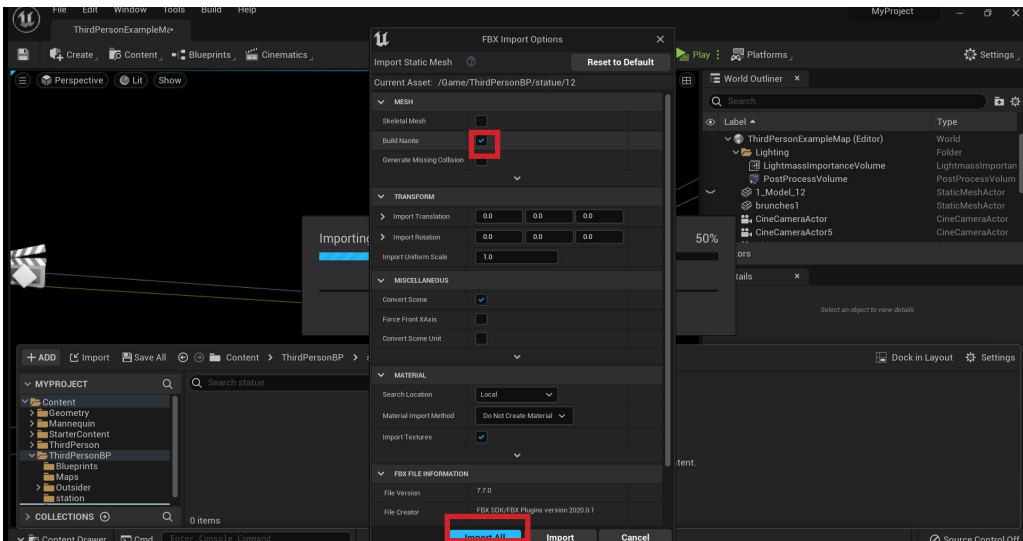


1 RENDERING IN UNREAL ENGINE 5

First, open your Unreal Engine and press ctrl and space to to the bar under your screen.

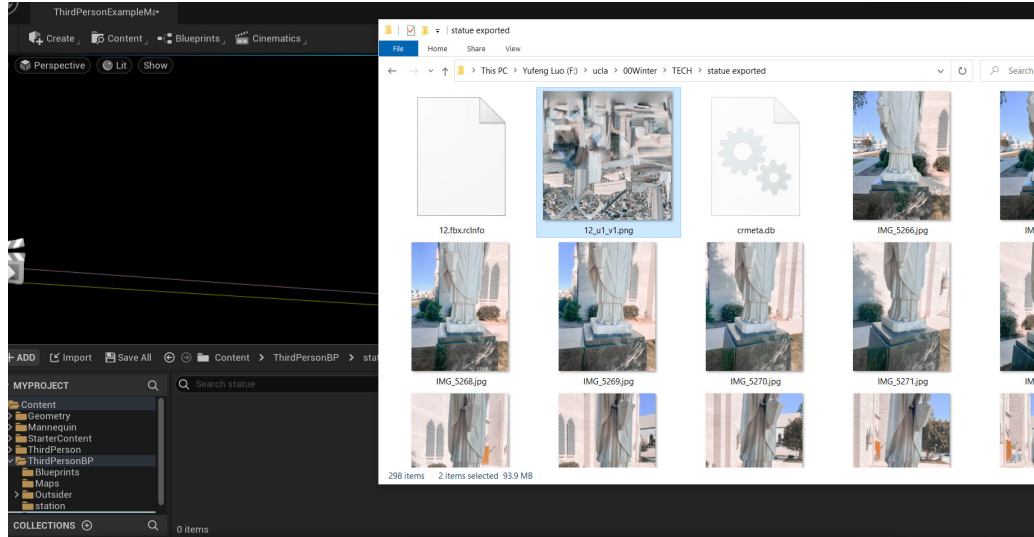


3 Then you will see this chart. Check 'Build Nanite' and then 'Import all'.



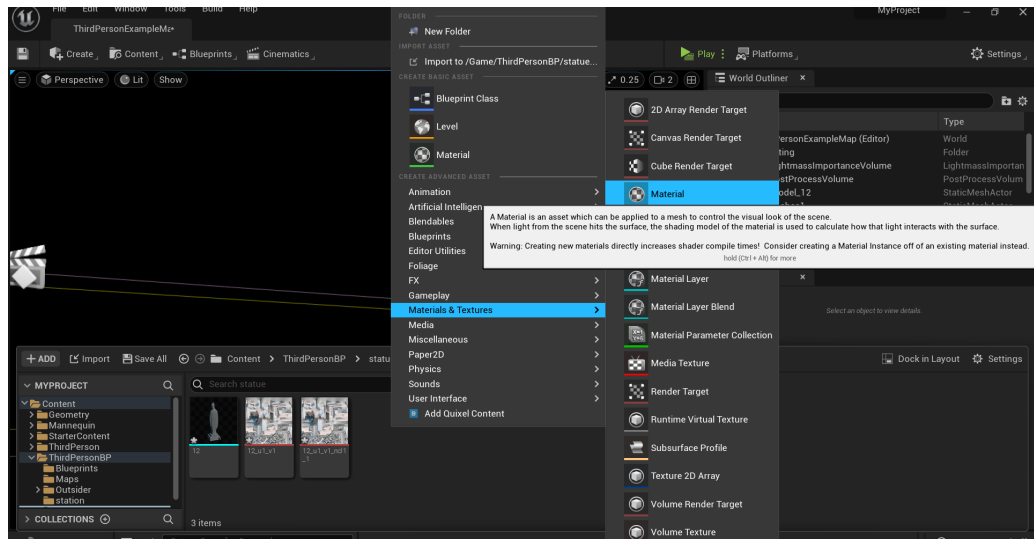
2

Open the folder containing your exported model and texture (picture) and just drag them into this bar.



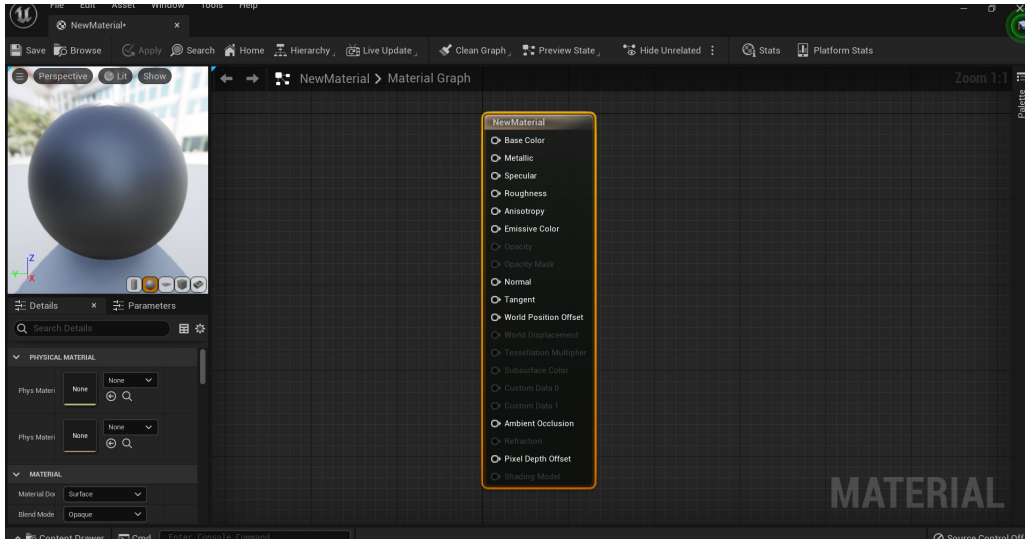
4

Then right click the blank in the bar, move your mouse on 'Textures & Materials' and then move onto 'Material'. In this case, you will get a material ball.



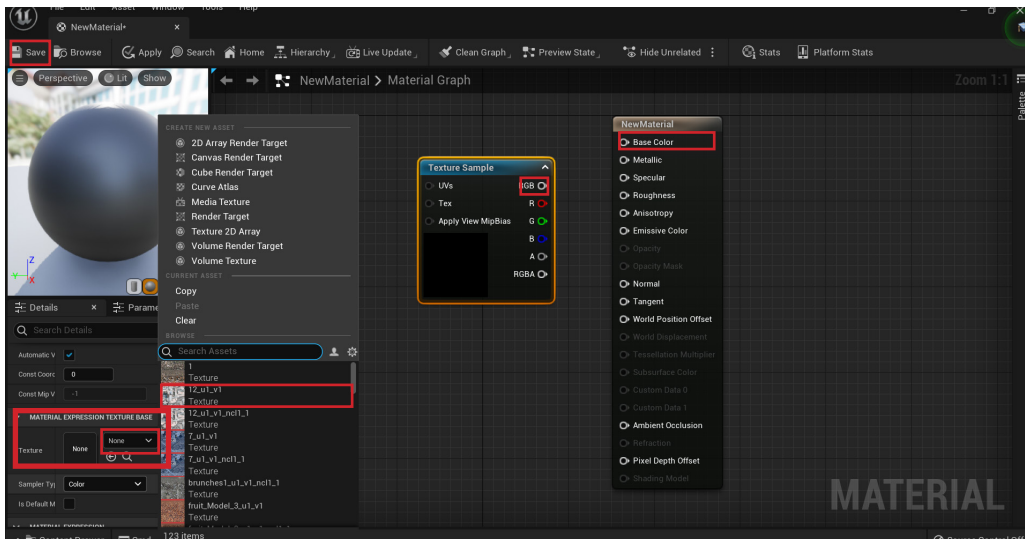
5

Double click on the material ball, to enter the material editor.



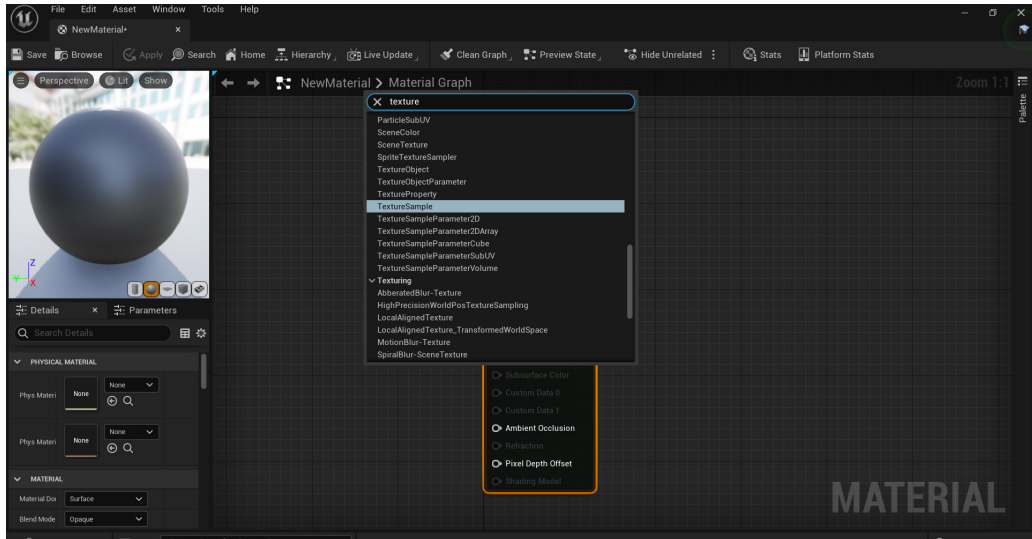
7

Click texture sample and you will see a new bar on the left side. Move your mouse onto it and scroll down to find 'Texture'. Then move your mouse to 'None' as marked and choose the texture (image) you just dragged in. Click and press 'RGB' and drag it to 'Basic color'. Finally, click 'save' on the left corner and close this window.



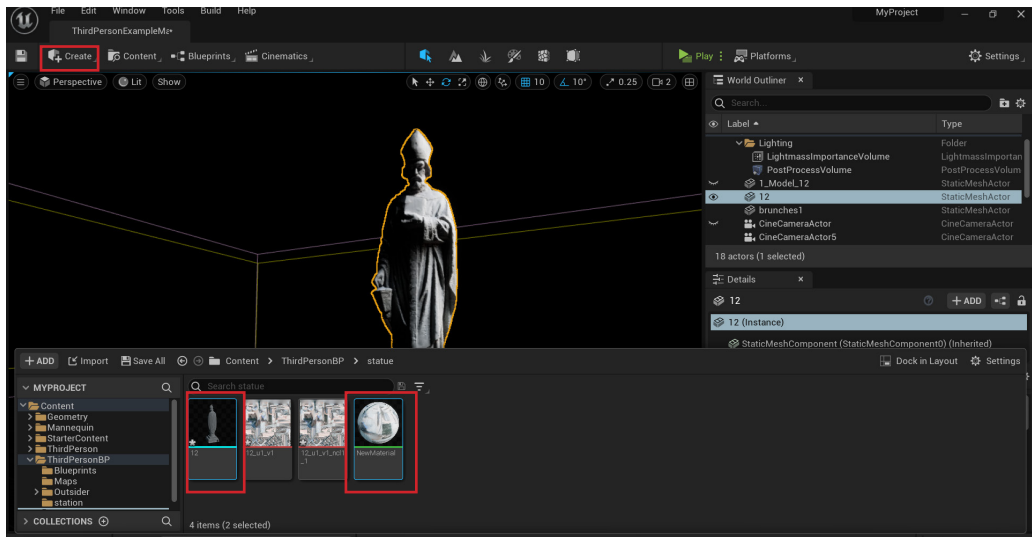
6

Right click on the blank part and type 'texture'. Then choose 'Texture sample'



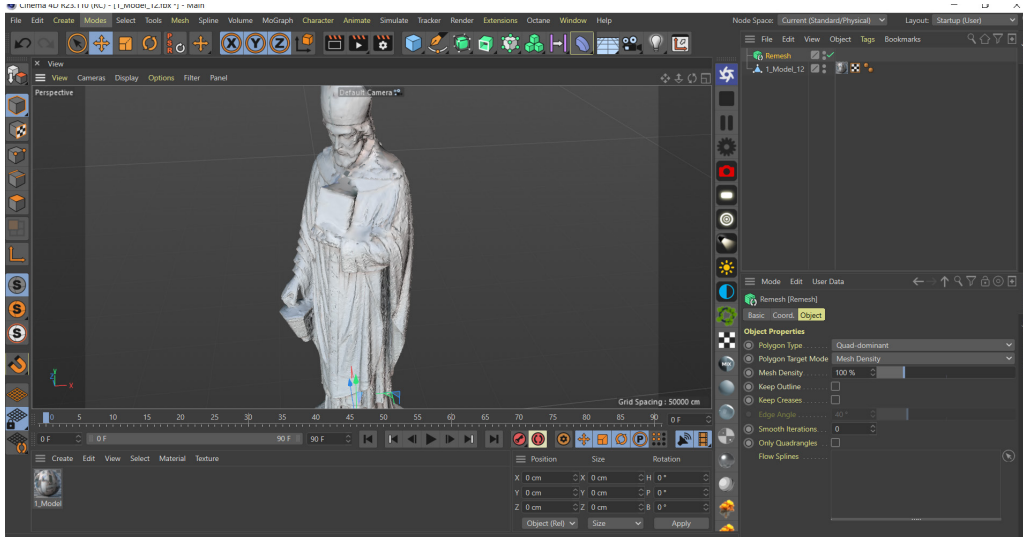
8

In the end, you just drag the model in the bar (if missing, click ctrl & space again to bring it up) to the empty space and also drag the material ball onto it. If the model's position is not right, use W, E, R, referring to Move, Rotate and Scale, to modify it. You can also click 'Create' to make some lights.

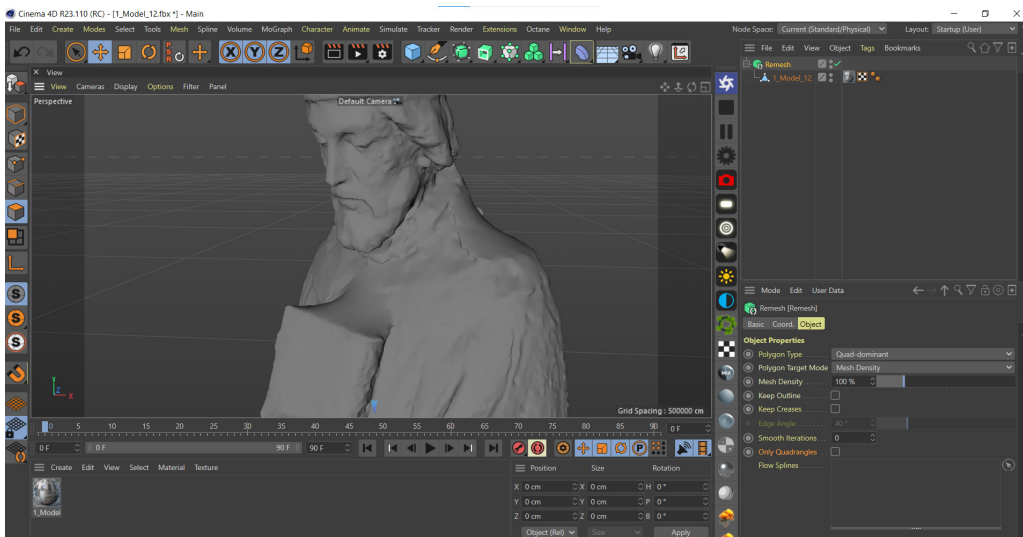


1 OPTIMISATION AND RETEXTURING (C4D R23 WORKFLOW)

First, open your model with C4D. Click 'File' and then click 'Open project' The model will be imported with a material ball.

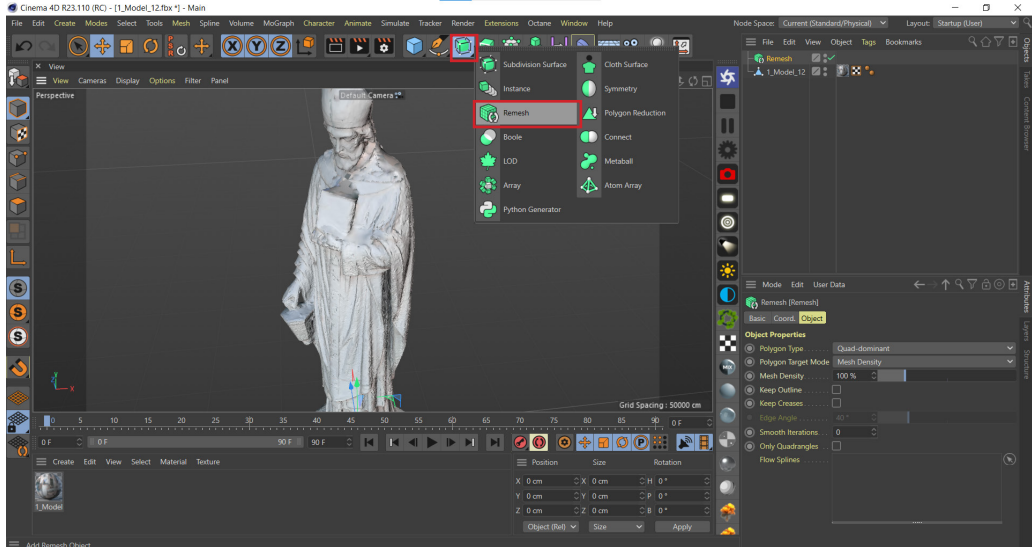


3 It will take a while to remesh it with quadrangles which are usually used for editing. However, sometimes remeshing will change the UV map of the model. So we have to bake the old texture onto the new one.



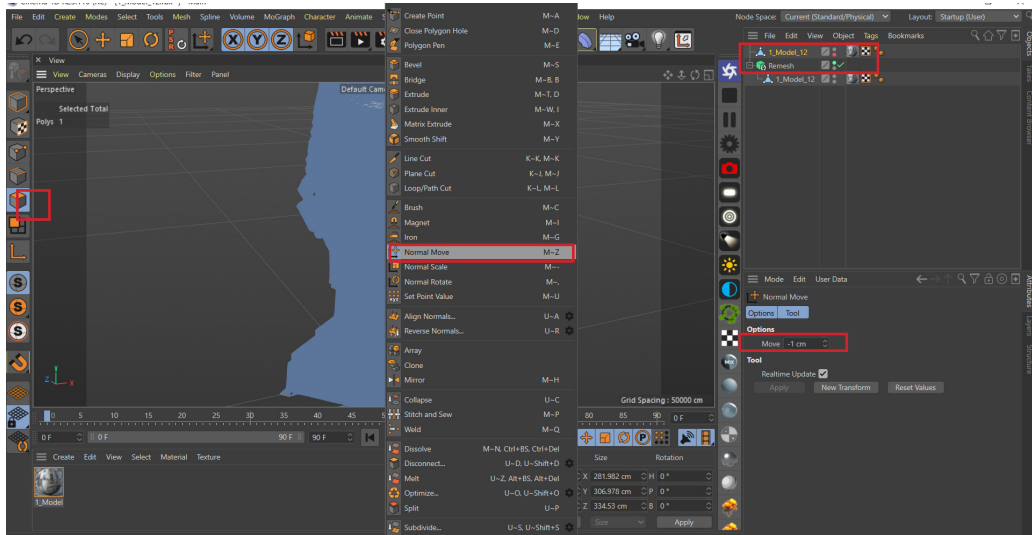
2

Click the marked icon and hold, then move to 'Remesh' to create a Remesh set. Then, drag your model in to Remesh.



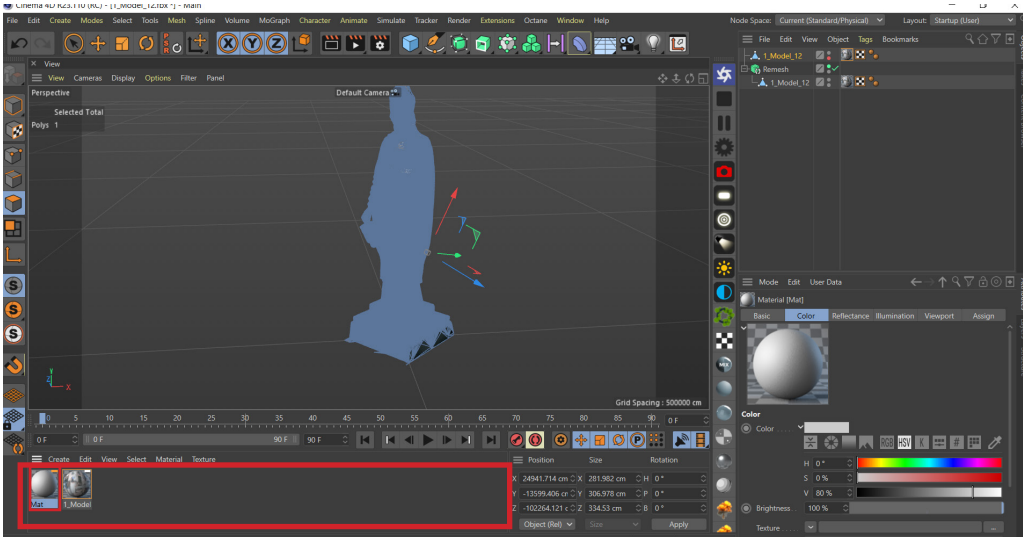
4

To bake material, first we need an original model (they should be in the same position). Then select the original one, click 'polygons' on the left side as marked, then move your mouse onto the model, right click and choose 'normal move'. Then just put in a small number like '10'



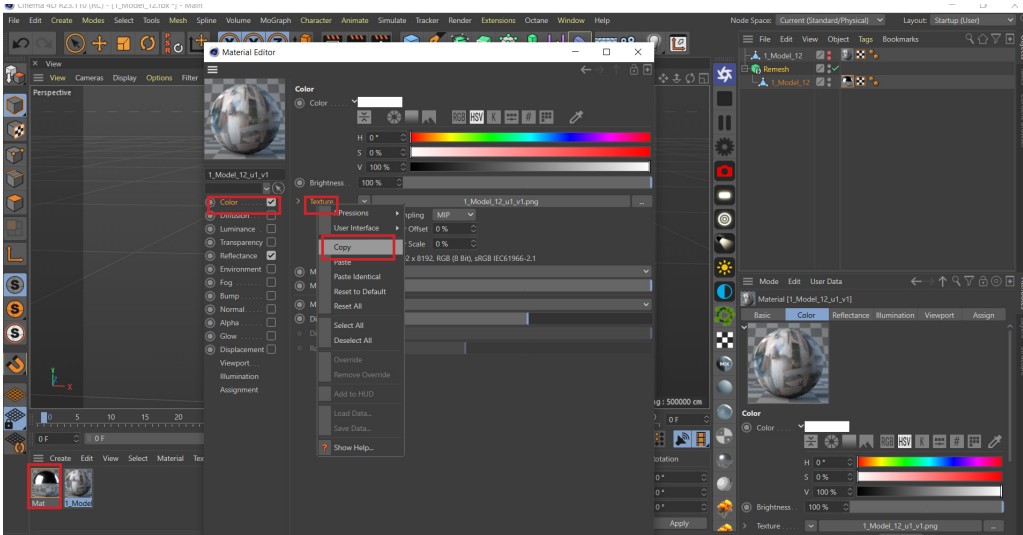
5

Double click on the marked blank site to create a new material.



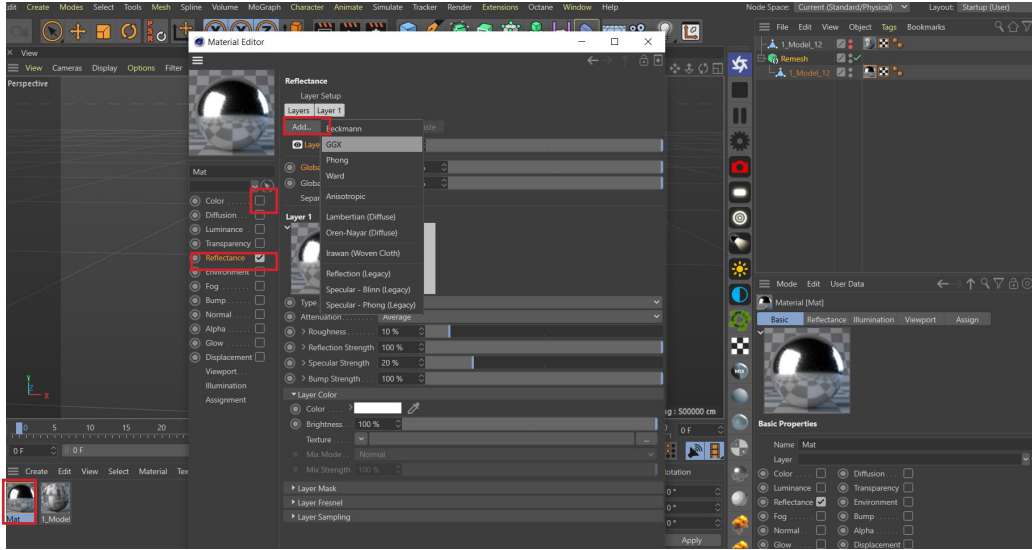
7

Double click the original material ball, uncheck 'color'. Click 'color' and right click 'texture' and choose copy.



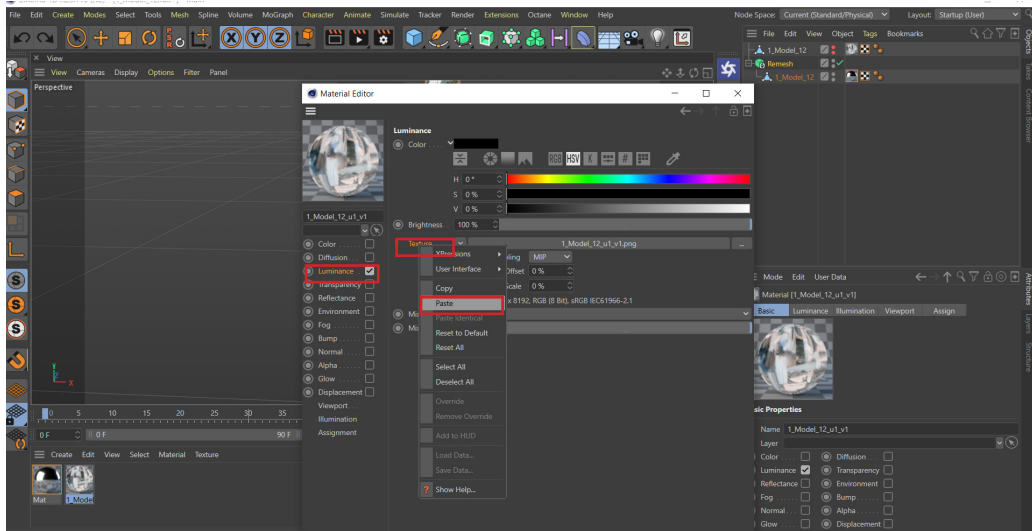
6

Double click the new material ball, uncheck 'color', check 'reflectance'. Click reflectance, then click 'Add', choose 'GGX' and close the window. Drag your new material onto the remeshed one.



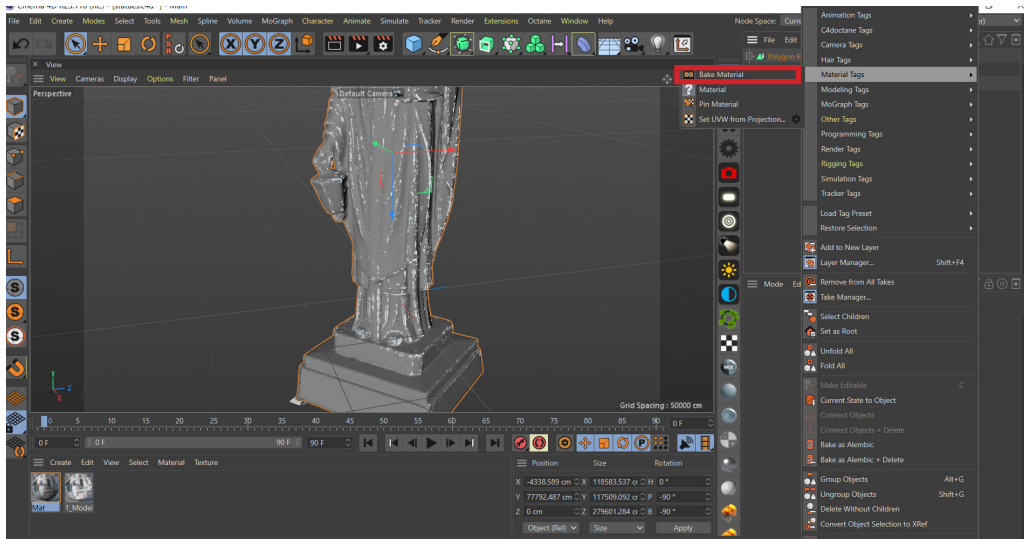
8

Go to luminance, right click 'texture' and click paste.



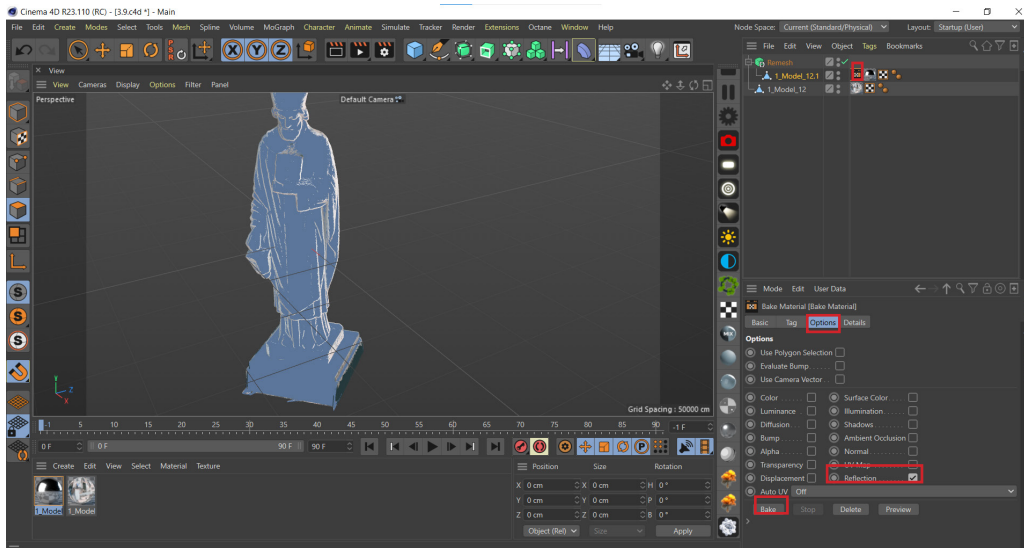
9

Right click the material tag of the remeshed mode, find 'Material tag' and choose Bake Material.



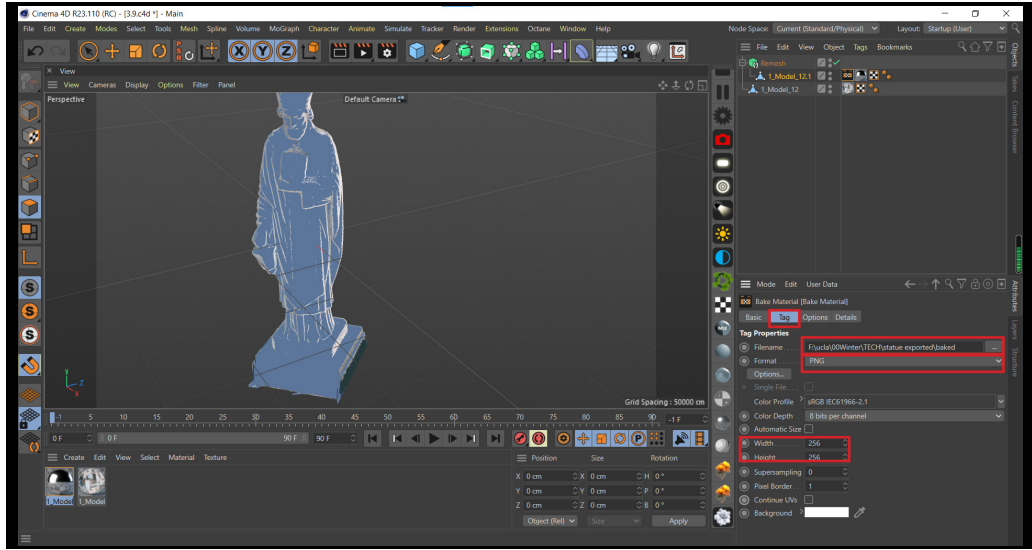
11

Click 'bake' tag and under 'option' check 'reflection' and click bake



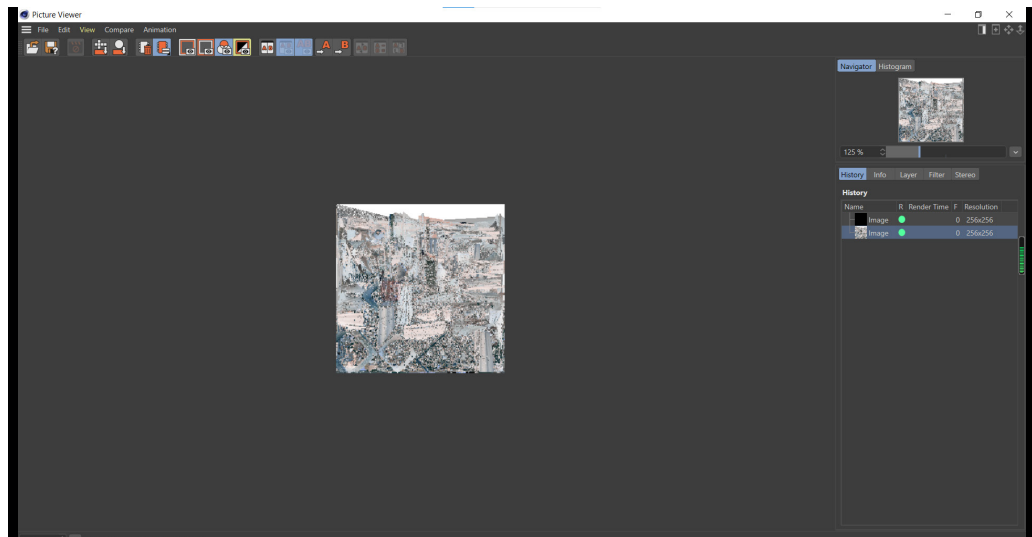
10

Click 'bake' tag and under 'Tag' in 'filename', choose where you want to save this texture, in 'Format' choose 'png', in 'Width' and 'height' set the resolution you want



12

Go to the folder you choose to save the texture, and apply it to your model.



FINAL OUTPUT

This is the online folder containing some of our successful results' vedios.

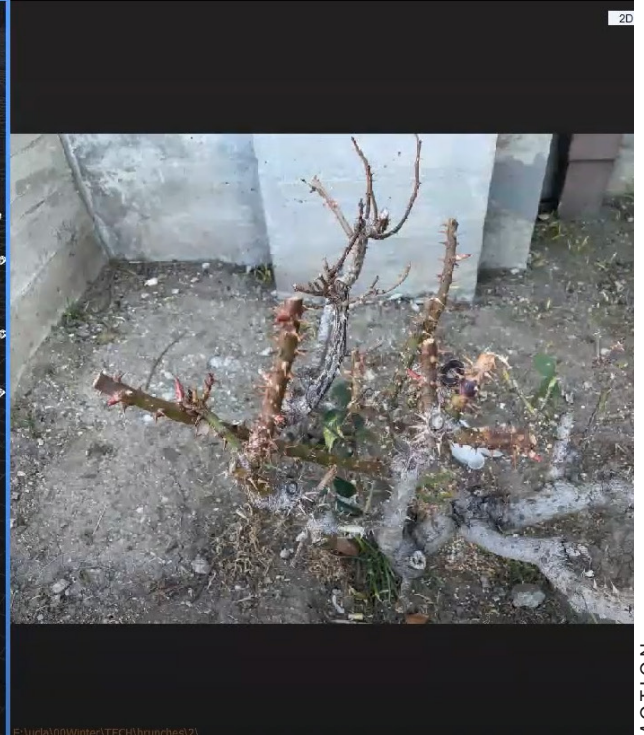
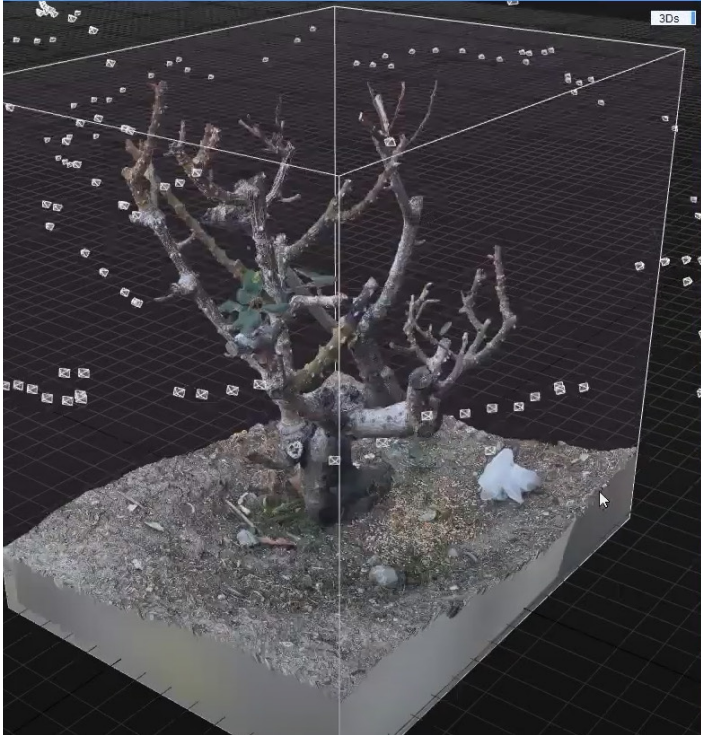
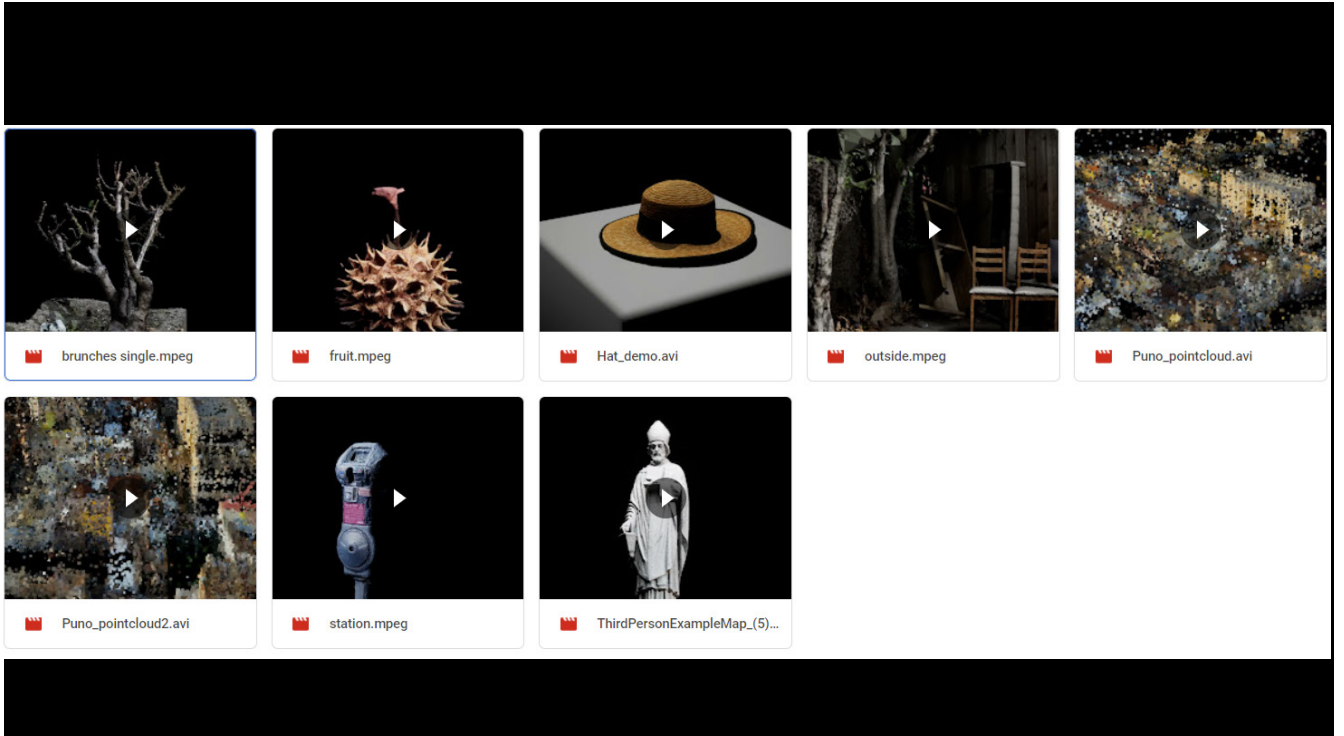
https://youtu.be/_LKxZXZxCy8

EXPLAINER VIDEO

This tutorial is very a very simple one, but enough for beginners.

<https://youtu.be/NsjqEaokps8>

There are more useful tutorials on Realitycapture offical website, like creating normal maps and using control points (we don't recommend it unless it is impossible for you to take photos of the items again)





KIMIA MOHAMMADI, YUFENG LUO, JINGJING FANG



- Con
- + TRA
- Ca
- ch
- Ci
- flc
- fr
- fr
- sa
- st

92 items

Tips & Tricks

About capturing process:

- The larger variety of the images, the better the photogrammetry result.
- Avoid reflective objects. If not taken care of, the photogrammetry software might identify the reflections, and the results would not meet up the requirements.
- Make sure that your object is well-exposed with enough lighting.
- Avoid large areas with solid colors. If this isn't followed, the software might not recognize the unique areas of the object. This will further result in a 3D mesh containing large holes.
- Use manual camera settings.
- Try to acquire every single corner of the object. This will help the photogrammetry software to deliver you better results.
- Patience and practice: Have patience until you achieve the perfect level of skill and practice it regularly.

About camera settings:

- In focus: High f-stop to avoid blurry background.
- No motion blur: Shutter speed 150+ to avoid handheld motion blur.
- Set the camera settings manually.
- Don't change the settings once you get the best result.
- The only thing that is auto is our focus.

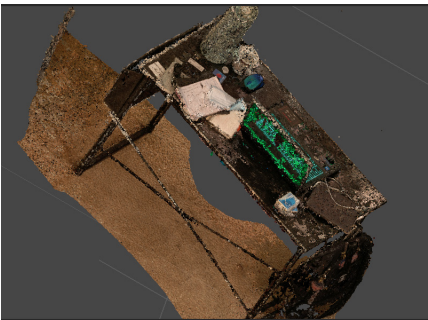
Troubleshooting



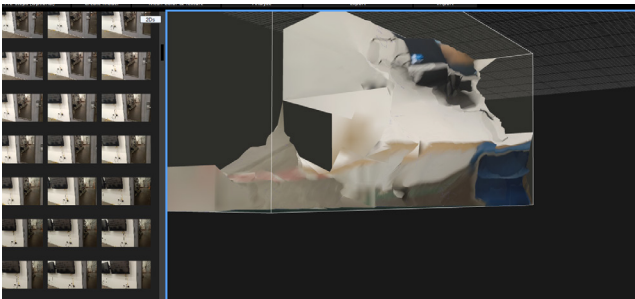
1. The shadow on the slipper causes hole on the tail.



2. The reflection of the remoter and table makes it hard to identify these two items.



3. In most cases, this kind result is due to lack of images or the light condition which casts too much shadow.



4. Don't use wide angle to film, which makes your image looks twisted. Just make it the same as your eyes see it.