3D SCANNING CLASS

6 Lessons Beginner Level

In this class, you'll learn everything you need to know to use your camera to take objects from the world around you and turn them into 3D models on your computer! I'll introduce you to the basic concepts of 3D scanning, and teach you an easily accessible method of reality capture called photogrammetry. Then I'll show you how to use a great program called ReCap Photo that will magically reconstruct your photos into 3D models in the cloud. Last you'll learn how to repair and edit your models to turn them into functional objects for all kinds of uses.

3D scanning is an amazing technology with all kinds of innovative applications from product design, to medical technology, to historical preservation, and beyond. What will you use it for??

Class Author:
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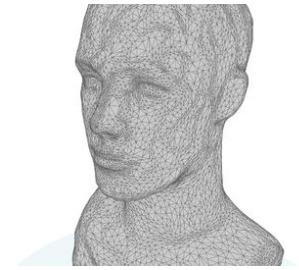
Mikaela is a F.I.T. trained costume and experimental fashion designer, who has done her best to make playing dress-up into a career. She has trained in both the costume and fashion design industries, and works with all kinds of materials and techniques including sewing, leatherwork, LEDs, fiber optics, painting, sculpture, laser cutting and 3D printing.

She is a former Artist in Residence at the Autodesk Pier 9 workshop, and currently an in-house content creator for the Instructables Design Studio.

Lessons

Lesson 1: Tools and Materials for 3D Scanning

Start off by going over the tools and software you need for this class with links for easy shopping.



Lesson 2: Understanding 3D Scanning

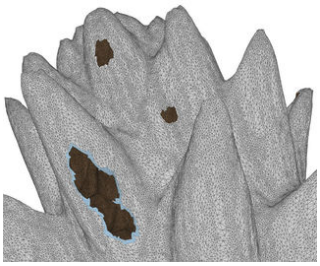
Learn the basic concepts behind the technology we'll be using and get ready to scan by downloading the software you'll need.

Lesson 3: Shooting for Photogrammetry

Explore the best lighting and shooting strategies for taking good photos to capture a variety of objects in different settings.

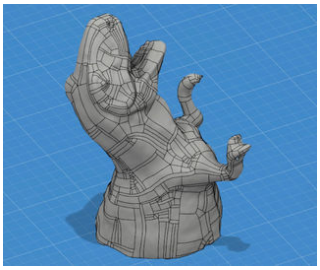
Lesson 4: Turning Your Photos Into a 3D Model

Upload your photos to ReCap Photo where they will magically be transformed into 3D models!



Lesson 5: Cleaning Up Your 3D Model

Learn the basic 3D modeling tools you'll need to edit your model and repair any errors.



Lesson 6: 3D Modeling Workflows

Take your 3D scan to the next level by exporting it to other programs or making it into a physical object.

LESSON 1: TOOLS AND MATERIALS FOR 3D SCANNING

The skills we are going to be learning in this class are mostly about technique and software understanding, not fancy equipment or supplies, but you will need a few basic things to get started. A lot of the tools on this list are optional because if you know what you're doing, you can get some pretty good 3D captures with a minimum of equipment. But in certain situations having some nicer gear will go a long way.

- Camera (anything from a phone camera to a fancy DSLR): Free-$800
- Tripod or monopod: $15-$100
- Chalk spray paint for shiny objects (optional): $15
- Lazy Susan or motorized photography turntable (optional): $50-$170 depending on weight of object
- White or black seamless photography shooting backdrop, paper roll or cloth (optional): $10-$75
- Diffused clip lights (optional): $20-$100
- Autodesk ReCap Photo (or another 3D capture program): ReCap Photo is part of ReCap Pro which is free for 30 days, $40/month for a subscription, or free for students or educators
- Autodesk Fusion 360 (optional): free forever for hobbyists, startups, students or educators
- Access to a computer with Windows 7, Mac OS X 10.9 or later and at least 12GB of RAM
- A three button mouse with a scroll wheel: $10-$30
- Access to a 3D printer or printing service (if you want to print your 3D model)
- Access to a Laser Cutter (if you want to create a 3D version of your model with Slicer for Fusion)
- Something to scan (preferably a medium sized, stationary matte object with some surface detail, we'll talk more about this soon)

Choosing a Camera for Photogrammetry

In this class we will be using a 3D Scanning method called ***photogrammetry.*** This method uses photos taken from multiple angles to reconstruct a 3D model of an object with both geometric and visual features. In order to perform this kind of 3D reality capture, you will need a camera.

If you have a phone with a good camera, it should be a perfectly adequate tool for shooting the photos you will need. However, if you do have access to a fancier DSLR camera, or want to spend some extra money, a higher quality camera will generally give you better results, especially if you know how to use one.

A high megapixel DSLR camera with a 35mm lens, and manual and automatic capabilities will give you the best options for capturing very good photos for photogrammetry, but a point and shoot with some manual features will work pretty well too. It's really just up to you to choose a camera you feel comfortable with.

Before you go spending money on an expensive camera, I would suggest trying the camera you have, and seeing what sort of scans you get after following the shooting strategies I recommend in the next few lessons. If you still aren't happy with the results, you might need to upgrade. For more tips on choosing cameras and understanding how to control their basic functions, you can check out audreyobscura's awesome Photography Class.

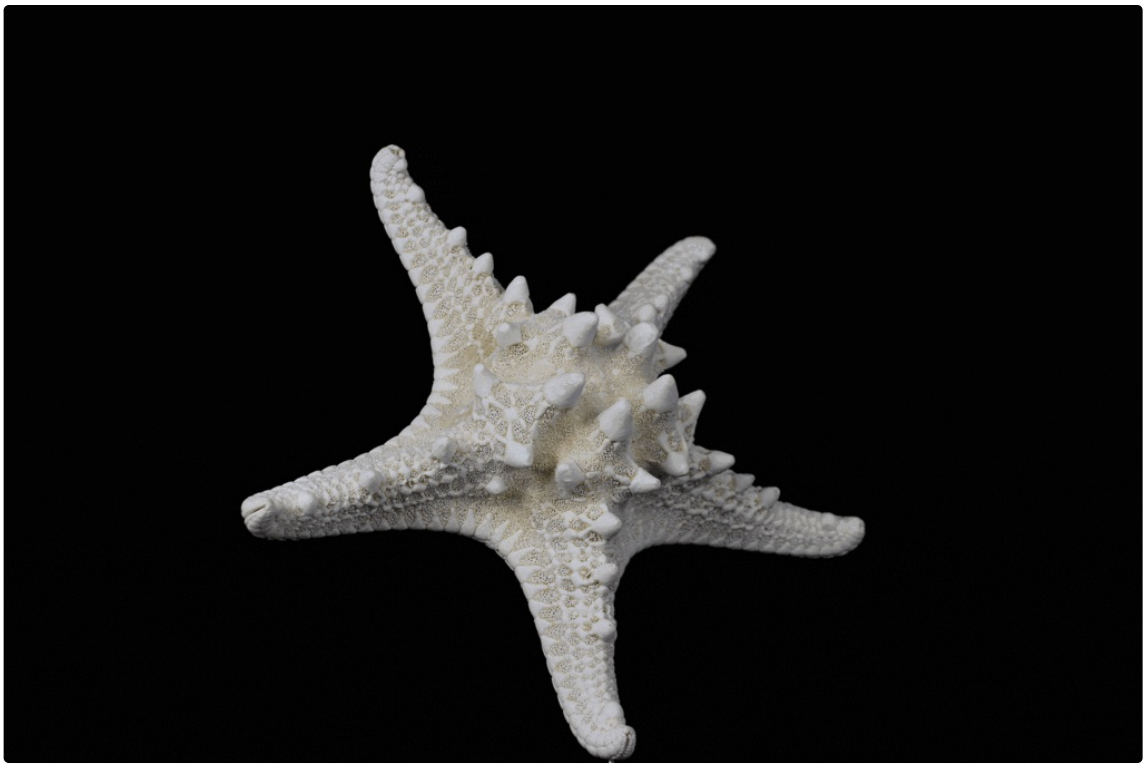
3D Capture Set-Ups

Accurately capturing an object with photogrammetry depends partially on how you set up your object in relation to your camera and the environment.

The two basic scanning strategies are:

Moving your camera around an object

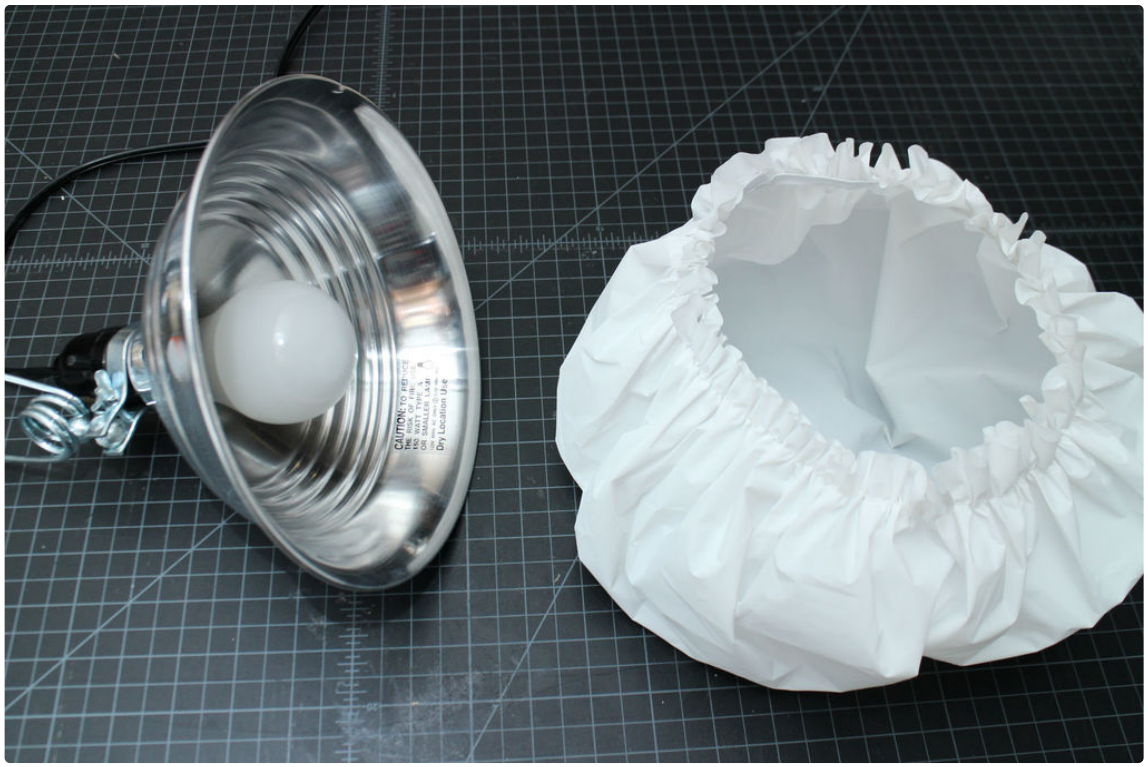
Leaving your camera stationary while rotating the object



I usually prefer the second method, because it gives you more control over your lighting and let's you take really consistent photos. But either method can work well depending on how well you set up and use your camera, so I'll be showing you how to do both in this class.

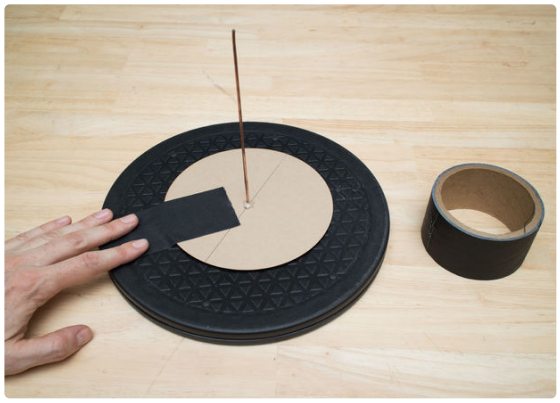
To shoot around an object, the minimum amount of equipment you'll need is a camera and an evenly lit space to shoot where nothing is moving in the background. However, having a tripod or monopod for your camera will really help you get clear, consistent shots, especially if the lighting conditions aren't great. I would highly recommend investing in a tripod, and you won't need anything special or expensive.

The right kind of lighting is crucial to photogrammetry, so If you can't find even natural lighting, you'll need to have a few diffused portable lights. You can buy more pricey versions of these lights or you can create a relatively cheap DIY version using clip lights and shower caps by following the project in this lesson of audreyobscura's great Photography Class.



Elevating the object you are scanning on a pedestal or stool will help make it easier to walk around, and also isolate it from it's environment in a way that can create a cleaner 3D model.

In addition to this, you may need a way to fixture some objects in a specific position to capture as much of them as possible in your scan. For example, to scan this artichoke, I created a simple fixture by pounding a nail through a square of plywood and sticking the stem of the artichoke on the nail, and when I was using the rotating object method, I attached a stiff wire spike to my lazy susan to hold small objects.



To shoot a rotating object, you need slightly more equipment. First of all, you will need some kind of manual rotating turntable or lazy susan to place your object on. Depending on how large or heavy your object is, you will need a different sized turntable. You could also make your own fairly easily by following this Instructable by the awesome tomatoskins.

When you are shooting a rotating object, you need the background to be as featureless as possible (I'll explain the reason for this later) so you will need to shoot against a seamless backdrop, a sweep, or inside a shooting tent. Black backdrops tend to work best unless your object is especially dark.

For this method you **absolutely** need a tripod to hold your camera in one place and some kind of lighting set up like the one described above. Another good lighting option for this type of shooting is a ring light that goes around your camera lens.

If you are really ambitious, you can try creating some kind of automated rotating capture rig like this one by Downunder35mm.

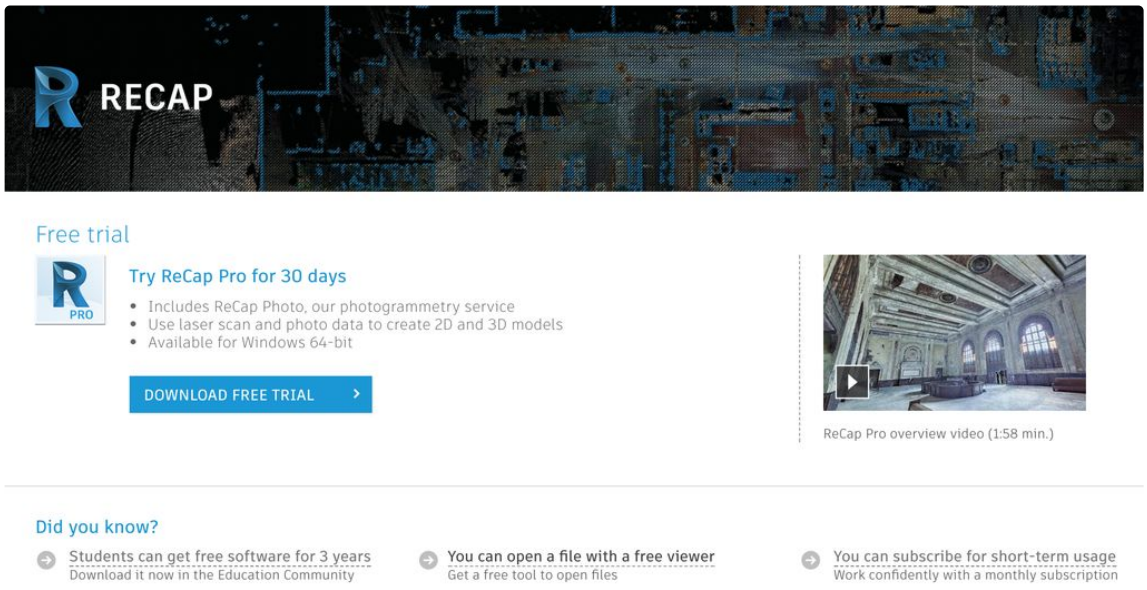
Software Options

There are a lot of software options on the market that will turn your photos into 3D models, but the Photogrammetry software I'm going to be teaching in this class is called ReCap Photo (formerly Remake). In the interest of full disclosure, ReCap Photo is an Autodesk product, and Instructables is an Autodesk company, so my choice of software might seem like a biased choice, but I still think it's a good choice.

The technology of photogrammetric reconstruction is relatively new, and still evolving. Autodesk has been exploring this realm for quite a few years now and ReCap Photo incorporates what they've learned from several other software platforms including 123D Catch, Memento, and ReMake.

ReCap does not just reconstruct it is also and end-to-end product that allows you to edit your meshes, perform simple sculpting and export for all kinds of applications. I also think the ReCap interface is simple and user friendly especially for someone just starting out with 3D modeling.

ReCap Photo gives you the option to processes your photos on the cloud, which means you don't have to have a super powerful computer and lots of extra hard drive space to create 3D models, and 3D files are returned to you quickly.



You can try a 30 day trial of ReCap Pro with ReCap Photo for free, which gives you the ability to upload unlimited photos and create as many models as you want in that time. After that you can choose to purchase a pro version for $40/month or $300/year. ReCap Pro is free for 3 years for educators and students though! And the definition of student and educator is fairly broad here, so if you can, try to register for an education license.

The one downside is that ReCap Pro is only available for Windows. But there are ways around this if you are a Mac user like me. You can install Windows on your Mac using Bootcamp so you start your computer with either a Mac or PC interface, or use Parallels to run both systems simultaneously. You can also subscribe to Frame for $10/month which will give you a virtual cloud based Windows desktop.

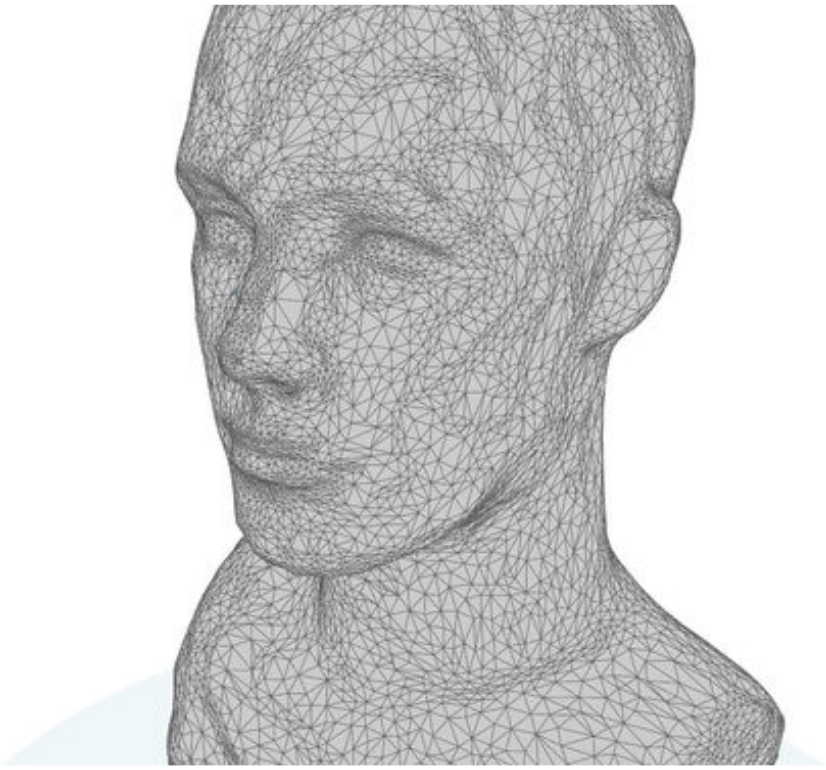
If you are already familiar with another software platform, or have free access to something other than ReCap Photo, feel free to use what you are comfortable with. Most of the photo capture techniques, workflows and 3D modeling concepts I'll be covering in this class will

probably translate fairly well to another program even if the specifics are slightly different.

Coming Up Next...

In the next lesson we'll get you ready for 3D scanning using photogrammetry by learning a bit about how it works and what it can be used for. Then I'll show you how to download and set up ReCap Photo, and give you a brief orientation to the program.

LESSON 2: UNDERSTANDING 3D SCANNING



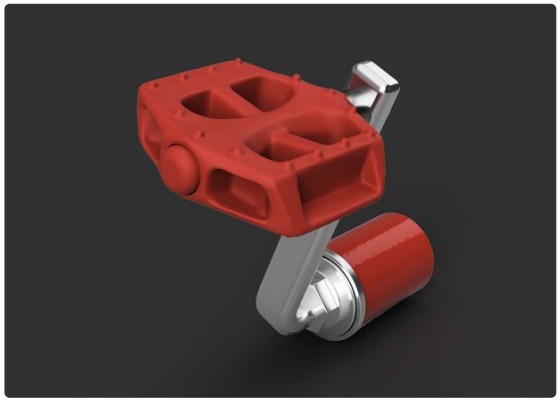
In basic terms, **3D scanning** is a form of reality capture that allows you to recreate objects from the world around you in 3 dimensions in digital space. Different types of 3D scanning use different strategies to collect and process the data needed to translate the geometry of physical objects into 3D models. Some types of scanning create models that are purely geometric, and some also capture color data. Once you have a scan of an object in a 3D modeling program on your computer, there are all kinds of ways to use that model, from scientific research, to art, to industrial manufacturing.

The technology and processes that make 3D scanning possible are extremely complex, and I am not going to dive too deeply into them in this class. There are a few basic concepts about how 3D scanning works - and how 3D models are represented in digital space - that will help you get better results in your own reality capture adventures. In this lesson, I'll go over some of the basic types of 3D scanning and then talk more about the most easily accessible reality capture method called Photogrammetry. I'll also show you how to download and set up the 3D reconstruction software we'll be using.

What 3D Scanning Is Used For

3D scanning or reality capture is a relatively new technology with a lot of exciting possibilities and diverse applications. Scanning gives you the ability to transform objects in the real world around you into 3D models in digital space. Once you have a digital representation of a physical object you can use it for anything from 3D printing to video game design and a million things in between.

In the product design world, going back and forth between physical prototypes and digital models with the help of 3D scanning can help streamline the design process, and create products that are ergonomic or designed to fit into unusual spaces.

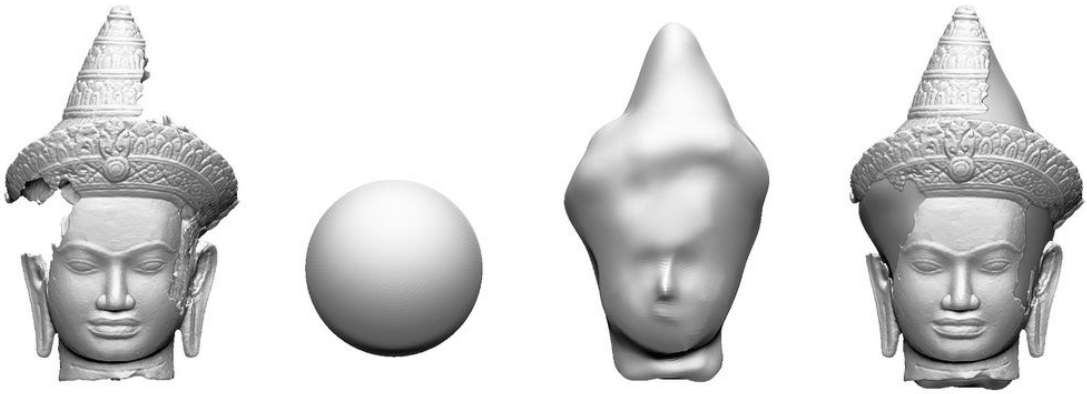


Architects and contractors use large scale 3D scanning to map whole structures, rooms or landscapes, helping them measure areas and design site-specific buildings or other features.

Game and VR designers use 3D scanning to capture elements of reality that can be incorporated into virtual worlds.

An increasing number of scientists, archeologists, and museum curators are using 3D scanning to capture and preserve natural and historical objects. Capturing 3D data about natural systems such as coral reefs allows biologists to observe changes that occur over time and study delicate ecosystems without damaging them.

Creating digital models of historical artifacts also helps protect them from wear and tear as well as allowing them to be shared online and accessed by a much larger community. In recent years, several projects have even used 3D scanning to digitally recreate historical objects that have been destroyed by acts of war or terror. By collecting hundreds of photos taken by tourists and curators, and using a process called Photogrammetry (the 3D scanning method we will be using in this class), an object that no longer exists can effectively be given a new life, which I think is pretty magical. You can read more about historical artifact reconstruction in this Instructable by leFabShop.



leFabShop

Another one of my favorite applications of 3D scanning involves creating 3D printed prosthetics for children with limb differences. Because kids grow so fast and limb differences come in many variations, having traditional prosthetics made for kids is often expensive and impractical. Groups like Enable are an international community of online makers who use 3D scanning, modeling and printing to create fun, inexpensive, customizable prosthetics for kids of all shapes and sizes! Check out this awesome Instructable by Amy Karl for more info about 3D Scanning for prosthetics.

When you are just starting out with 3D scanning, you might not be using this technology such complex applications, but there are a lot of other fun simple things you can do with scanning, like these Starfish Earrings I made with one of my scans. You can also check out the future projects collection at the bottom of the class page for some great examples of how other makers have gone wild with this technology.

Types of 3D Scanning

Several different types of scanning technologies have been developed for translating the three dimensional real world into digital 3D models. Some methods are more accurate than others, some are better for different applications and others are simply hard to access outside of specific scientific and industrial contexts.

Photogrammetry: the most easily accessible form of 3D scanning, and the one we'll be using in this class, photogrammetry uses photos taken from multiple angles to reconstruct an approximate 3D model of an object. Because it is taking data from photos, this method can also recreate the color and texture of an object mapped onto the 3D surface. This makes it especially great for creating models that are going to be used in digital applications like gaming, VR, architecture, etc, but it can also be used to make models for 3D printing and other physical applications.

Structured Light Scanners: this type of scanner captures an object by projecting a pattern of light onto the surface while simultaneously photographing the object. Measuring how the light pattern distorts as it moves over the surface of the object allows the scanning software to recreate the object in 3 dimensions. These scanners can be very accurate once you know how to use them, but they can also be very fussy often take awhile to master. They are also expensive, and the software that accompanies them is usually clunky.

If you want to know more about the process of using a structured light scanner, check out this Instructable about the Autodesk Pier 9 scanners by gabrieltaft. The gif above shows the artist Amy Karl being scanned by one of the Pier 9 structured light scanners. You can check out more of Amy's amazing work here.

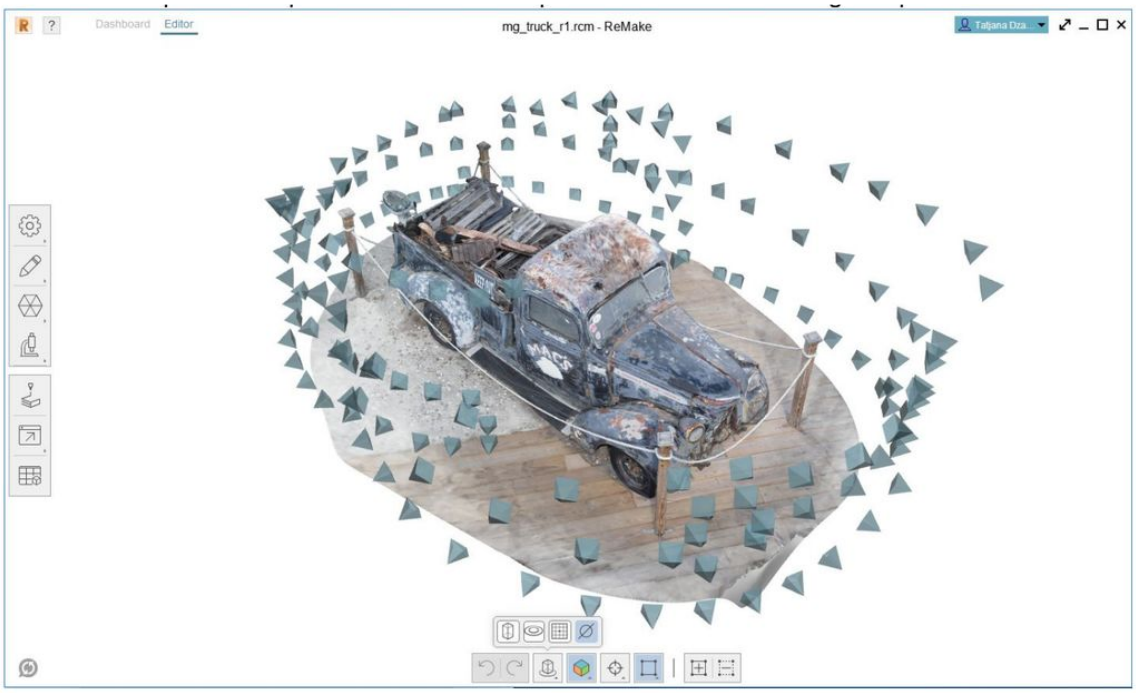
Laser Scanners: another relatively common 3D scanning technology, laser scanning maps an object by projecting a laser dot or line onto the surface and measuring the distance to the object at different points. By triangulating these points with the location of the scanner using photos taken at the same time, a 3D model can be constructed. These scanners can create extremely accurate models when used properly, but, like structured light scanners, professional versions are expensive.

If you want to know more about the process of using one kind of laser scanner, check out this Instructable by gabrieltaft about the Next Engine scanner we have at Pier 9.

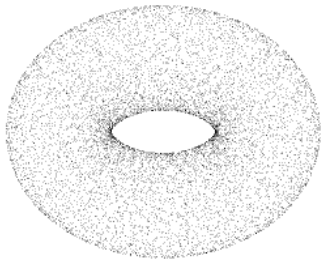
Or, if you are up for a challenge and have access to a 3D printer, you can try following Instructables user Sardau's tutorial for creating this amazing open-source 3D laser scanner for around $30!

How Photogrammetry Works

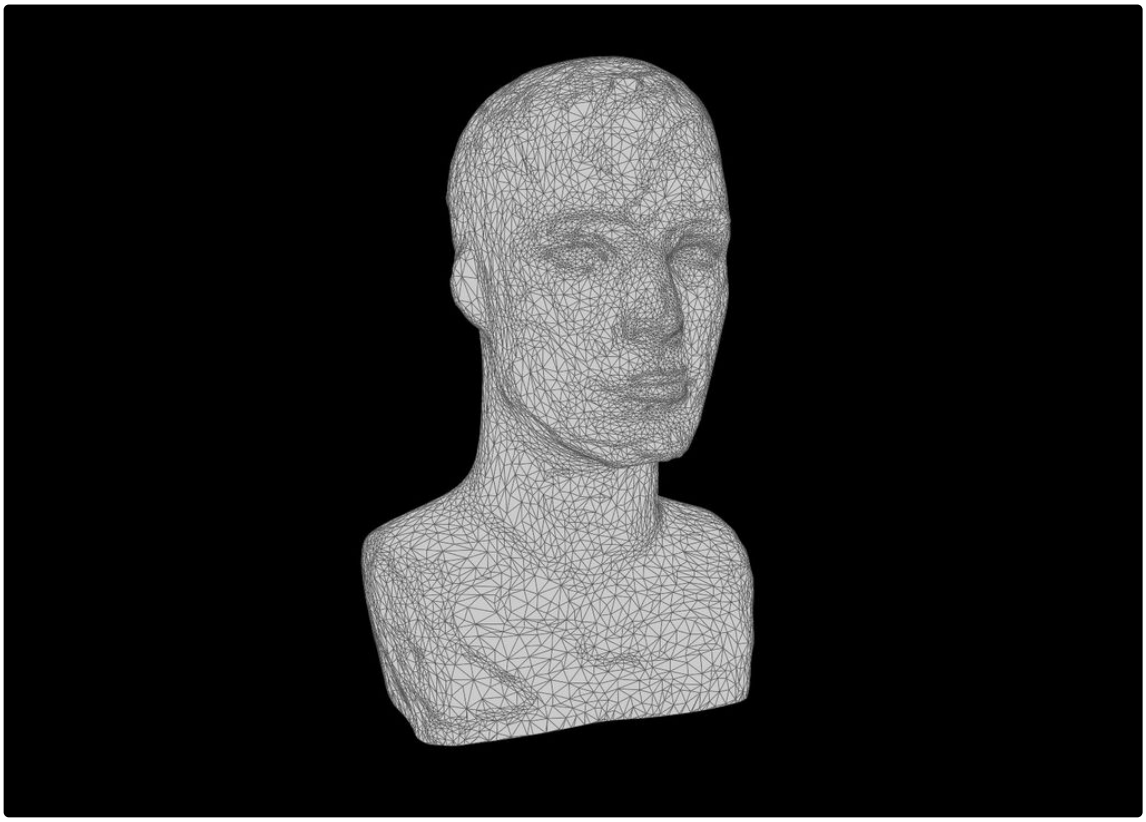
All you really need to create 3D models with photogrammetry is a camera and access to software that can perform the complicated algorithms required to magically turn a bunch of 2 dimensional images into something 3 dimensional. It can be a bit tricky to create perfectly accurate models with this method, but with a few tips and a little practice you can get incredible results without needing access to an expensive 3D scanner.



To photograph something for photogrammetric reconstruction, you need to take a series of overlapping photographs of an object from different angles. Photogrammetry software detects features on your object finding common points in overlapping pairs of photos which can be used to find the camera's placement in relation to the object for each photo. By solving for all of the common points simultaneously, the software builds a 3 dimensional representation of the object made up of individual points on the surface. This type of model is called a ***point cloud***.



Point clouds are not quite true 3D models, but simply a set of points on a 3D coordinate system. They can be used for some applications like architecture and site scans that don't need to be edited. But for many workflows, point clouds need to be converted into a different kind of model in order to be useful. Most photogrammetry software does this automatically, connecting the dots of the point cloud and filling in the spaces to create a solid surface called a ***mesh***.



Mesh models come in different kinds based on how the dots have been connected to form the surface of the model. Meshes can be made up of triangles or polygons, and different

types of meshes are better for different purposes. ReCap Photo automatically creates triangle meshes which can be edited and sculpted in the Recap Photo editing environment and programs like Meshmixer. To export 3D files for more advanced modeling you will often need to convert them to another kind of model, like a quad polygon mesh. We'll talk more about these types of workflows in the last lesson.

Choosing Objects to Scan

Because of the way photogrammetry works, some objects are easier to capture than others. The easiest scans are usually medium sized objects between about 8" and 36". Very small objects are also hard to scan accurately, as are objects that have a lot of crevices, or thin bits, like flowers or foliage. Very large objects also present problems because of the sheer number of photos required to photograph the entire object thoroughly, but with the right equipment, photogrammetry can even be used to capture rooms or landscapes, especially if you don't need an extremely detailed model as your final product.

Shiny, clear, or reflective subjects will be hard to capture because their surfaces look different from different angles which confuses the software. These kinds of objects can often still be scanned with some special preparation before they are photographed. Overly featureless subjects are also difficult because the photogrammetry software will not have enough reference points to reconstruct them.

Objects in motion are almost impossible to capture, which can make scanning the human body challenging, but definitely still possible. In the next lesson of this class I share a few tricks that will make capturing human subjects much easier.

With all this in mind, I'd suggest starting out with something medium sized, with a matte finish and some surface and color detail, but not too many complex cut-outs or delicate pieces. We'll talk more about how to deal with potentially tricky objects in the next lesson.

Free trial

Try ReCap Pro for 30 days

- Includes ReCap Photo, our photogrammetry service
- Use laser scan and photo data to create 2D and 3D models
- Available for Windows 64-bit

DOWNLOAD FREE TRIAL

ReCap Pro overview video (1:58 min.)

Did you know?

Students can get free software for 3 years
Download it now in the Education Community

You can open a file with a free viewer
Get a free tool to open files

You can subscribe for short-term usage
Work confidently with a monthly subscription

Recap Pro free trial

START OVER

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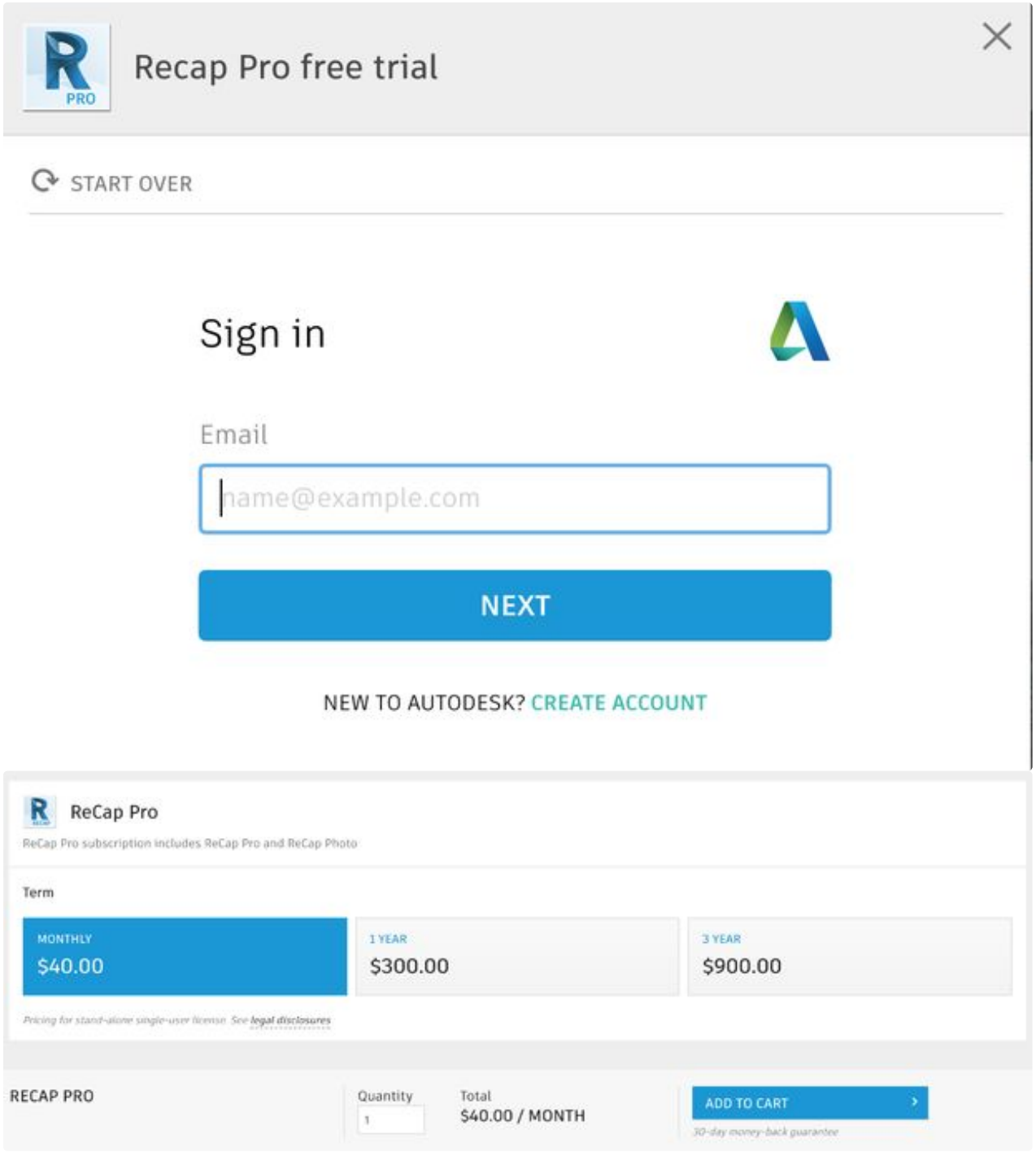
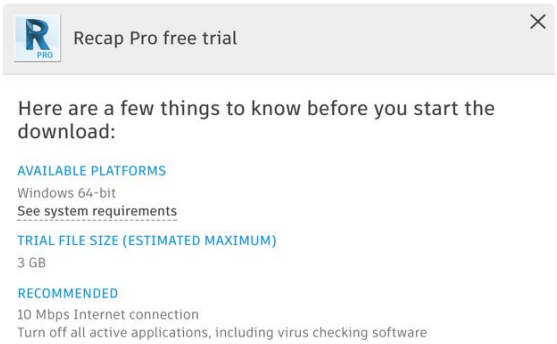
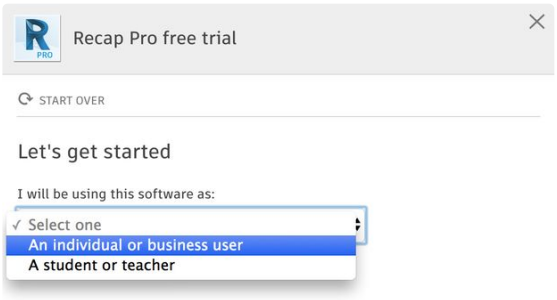


Downloading and Setting Up ReCap Photo

If you've chosen to use ReCap Photo, you'll need to download and install it on your computer. Remember that it has a 30 day free trial, so if you want to be able to test its full capabilities before committing to pay for it, don't download it and then go on a month long vacation before you try 3D scanning anything. After the 30 days, you will only have access to the standard ReCap software, which does not include the photo to 3D mesh capabilities we will be using in this class.

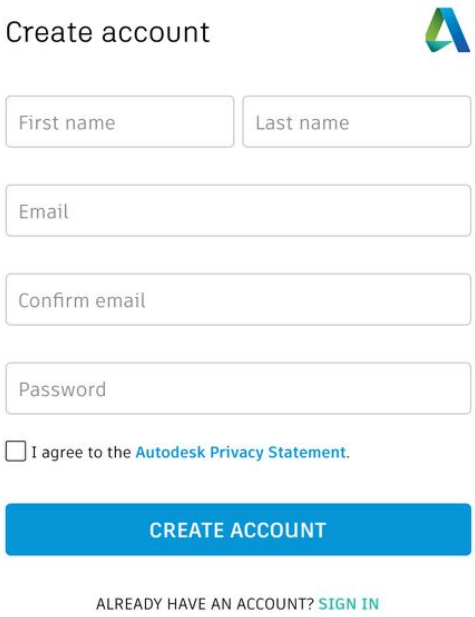
ReCap Photo is a 'cloud enabled desktop app' so, while some of its functionality takes place online, you will mostly interface with it through your desktop. Go to the https://www.autodesk.com/products/recap/free-trial, click on the download for your operating system, and go through the install prices to add ReCap Pro to your desktop. In order for the program to run properly, you will need at least 4GB or more of RAM, and 10GB or more of free disk space on your computer and Windows 7 or later. You can read the System Requirements for more info.





If you are a student or an educator, you can also register for a free three year education license here.

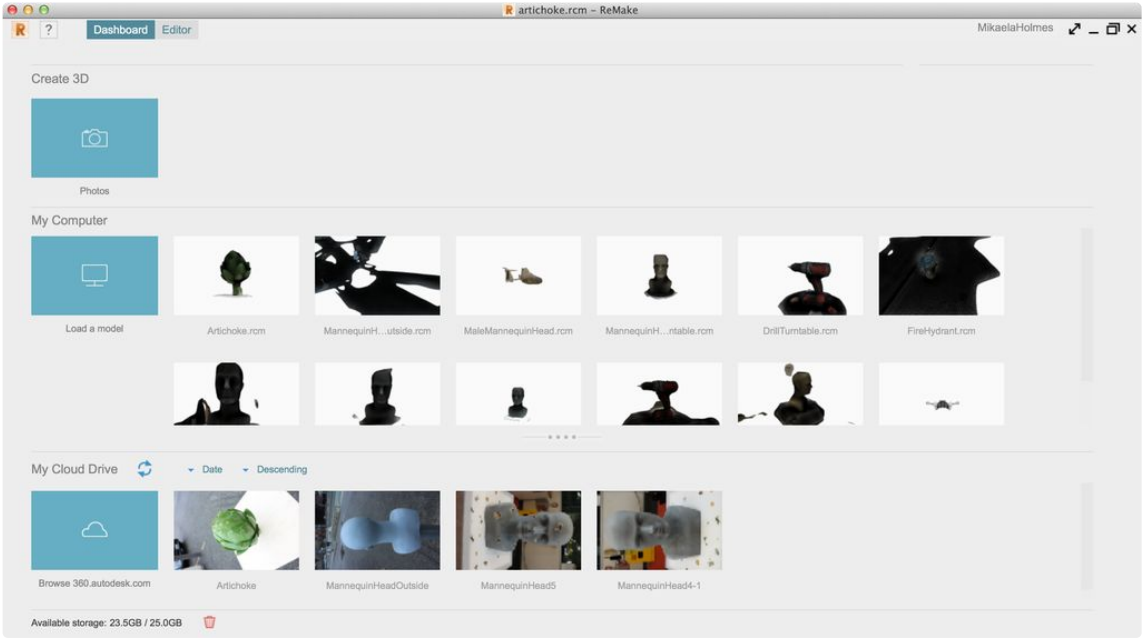
To use ReCap, you will need to create a free Autodesk account. If you don't have one, you will be asked to create one when you download or you can Go to https://accounts.autodesk.com/register and create a username and password. With this account you will also get 5GB of free cloud storage space that you will need to store the photo sets you upload to create 3D models.



Once you have installed ReCap Pro on your computer, open ReCap Photo and check out the interface. If you want to follow along with this video, I'll give you a little tour. I created this video when the software was still called ReMake, but the interface is nearly identical.

https://player.vimeo.com/video/205138498?title=0&byline=0&portrait=0

On your desktop you will see a tab for your 'Dashboard' and 'Editor'. The Dashboard is where you will upload photos to be made into 3D models, and access the models you have already created.

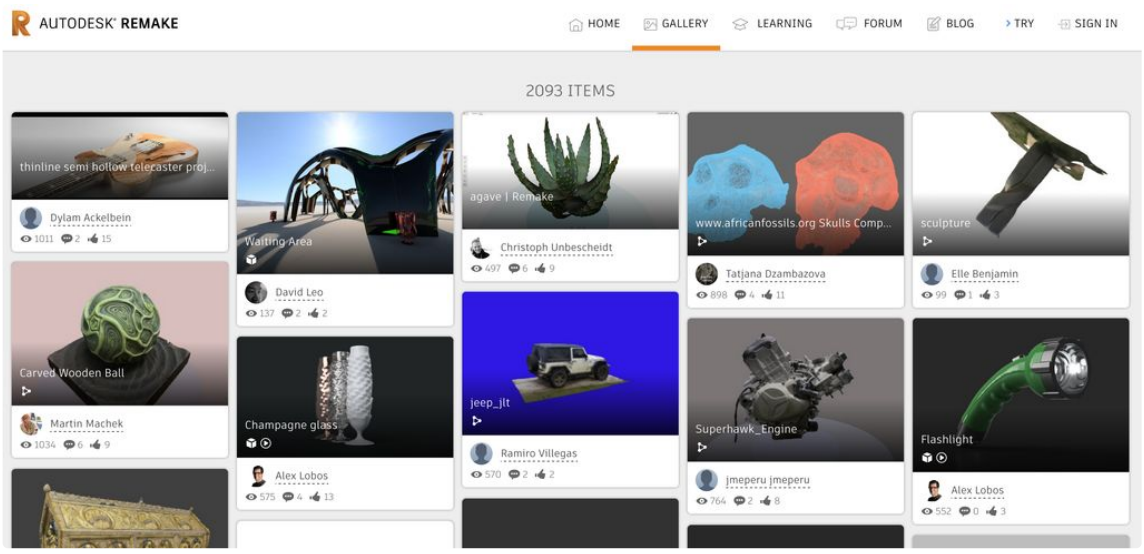


The editor is where you will work on individual 3D files.

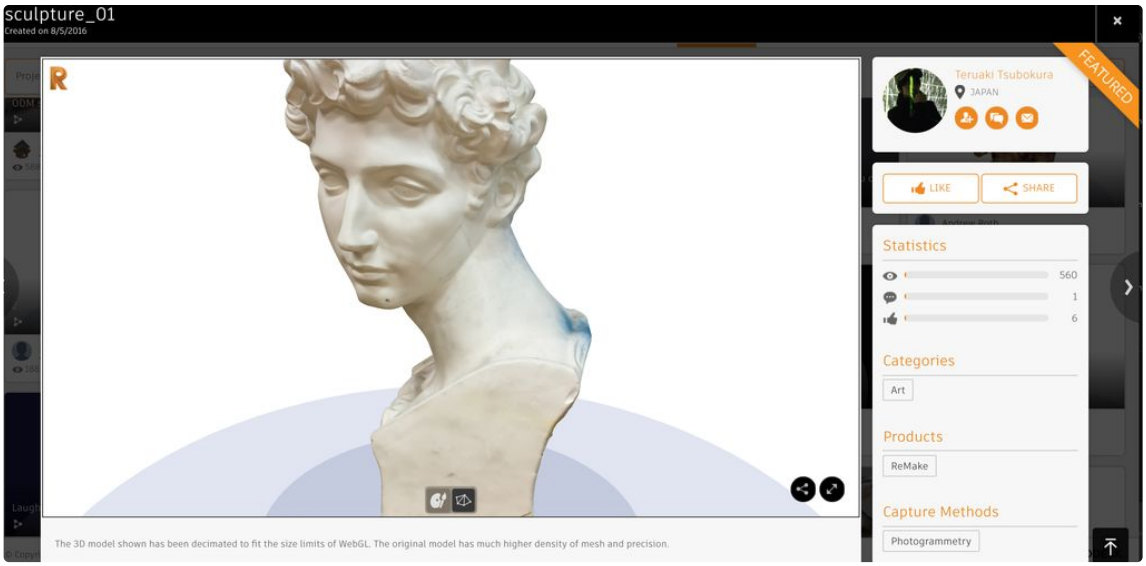
We'll talk more about navigating the desktop environments in future lessons, but for now, try exploring some of the features on the old ReMake site. I assume they will be migrating a lot of this content over to the new ReCap Pro site, but for now it still exists on the Remake site, and is still relavent. Check out this video for a tour of some of my favorite features of the site:

https://player.vimeo.com/video/205138529?title=0&byline=0&portrait=0

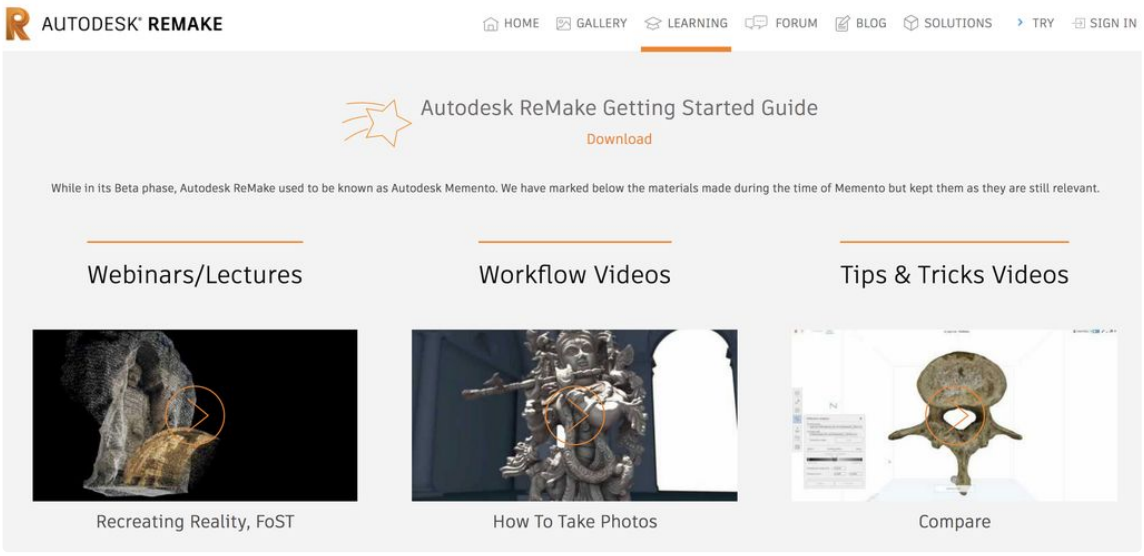
My favorite feature of the old ReMake site is the Gallery where you can browse thousands of scans that have been uploaded by users. It's a great place to get inspiration and even pick up tips.



Many of the models include data about how they were captured and users will often answer questions about how they created their models.



Another good section of the site to explore is the 'Learning' section. Here you'll find a PDF 'Getting Started Guide' and some videos that illustrate some of the fascinating ways remake is being used, as well as tutorial videos. I'll be covering all the basics of using ReCap Photo in this class, but if you come across something you can't figure out, you might find an answer here.



In the Next Lesson...

Now that you have ReCap Photo set up and a basic understanding of how photogrammetry works, let's start scanning! In the next lesson we'll talk about different ways to light and capture and object to get the best quality scans in different situations.

LESSON 3: SHOOTING FOR PHOTOGRAMMETRY

Being able to create something 3 dimensional from 2 dimensional photographs is definitely magical, but it can also take quite a bit of finesse to get the right kind of photos. In this sense, a large part of learning how to scan with photogrammetry is about learning basic photography and lighting technique, so I highly suggest also checking out audreyobscura's Photography Class for some great foundational information about camera operations and

Photogrammetry requires a very specific kind of photography, the aim of which is much more practical than aesthetic. Ideally every area of the object will be visible in at least two photos in order to give the reconstruction software enough points of reference to work with. There are a few different strategies you can use for your photo set-up depending on what kind of object you are shooting and your budget.

In this lesson, we'll talk about everything you need to know to shot your photos in different environments.

The Two Shooting Strategies

As I've mentioned there are two basic strategies when you are shooting for photogrammetry: you can either shoot by moving your camera around an object, or rotate the object while keeping your camera still. I'm going to show you both.

A lot of sources will tell you that shooting around an object is the most effective, because reference points in the background help the software properly orient your photos in space. In my experience, however the other method produces much better results when done properly. It requires somewhat more careful preparation and more equipment, but it allows

you far more control over your lighting and shooting environment.

When you shoot a rotating object, you need your background to be perfectly blank or featureless. This means you will need a black or white backdrop that is big enough to allow you to shoot your object from both high and low angles. You will also need a tripod, a turntable and usually some kind of artificial lighting set up to light your object and create perfectly blank background with no shadows.

Sometimes using this method will be impossible (say, if you want to capture a statue in an outdoor park) so depending on the object you are shooting and the equipment you will have available to you, you will have to choose for yourself which shooting method makes the most sense.

Getting either method right may require some trial and error, so try not to get discouraged. When I first started experimenting with photogrammetry, I was using the "shoot around an object" method, and I was having a lot of trouble getting good results. Eventually I switched to the "rotate the object" method, which worked a lot better for me, but some people have gotten great results from shooting around an object even with only a camera phone.

Preparing Your Object for Scanning

Depending on what kind of object you've chosen to scan, you may need to make a few preparations before shooting. As I mentioned in the last lesson, the easiest objects to scan with photogrammetry are stationary medium sized objects with a matte finish, a good amount of surface detail and not many thin delicate bits. So, if you've decided that you really want scan the large shiny tuna fish you saw swimming at the aquarium, or a tiny delicate flower with 27 petals... you might just want to re-think that decision.

If you have chosen something a bit more rational (such as, say, the mind blowingly natural fractal geometry of this romanesco) you will still need to make sure you have your object set up correctly so you get the best possible photographs.

It's often helpful to fixture your object in a certain position before photographing it. For example, If you have an object that you want to scan all the way around, put it on a mount that holds it above the surface you are scanning on. An easy way to do this for an object like my romanesco, is to simply take a board or piece of plywood and hammer a long nail or piece of stiff wire through the center. Then you can stick your object onto the nail like this. (Just be careful if you leave this spikey booby trap lying around. I drilled a hole in another piece of wood to cover my nail when I wasn't using it).

Depending on what sort of object you are scanning, you might need to construct a different kind of stand. Another good option is to use a small tripod with a clamp so you can clap your object or clap a nail that you stick into your object. Sometimes you might not even need to capture the underside of your object, in which case a stand might be unnecessary.

If you are trying to shoot an object that has some undesirable characteristics for scanning, there are a few things you can do to make getting a good scan more likely.

If your object is shiny reflective or transparent: if you need to be able to return the object to its original state, try spraying it with a removable chalk spray paint. If you don't mind altering the object irreversibly, you can use a regular spray paint or brush on paint,

just make sure you use something that is matte not glossy. Even small shiny areas on an object can sometimes cause problems in reconstruction, but sometimes just covering these areas up with carefully placed pieces of masking tape can help a lot.

If your object doesn't have a lot of surface detail: objects that are all one uniform color sometimes don't have enough points of reference for photogrammetry to use in reconstruction. So,if you are scanning an object like this mannequin head and you don't care about capturing the color layer, you can add your own details by drawing on the surface, or sticking stickers or pieces of tape on the object.

If your object is very small: if you determined to try scanning a very small object, you will need a camera with a very good macro lens and a tripod so your images come out extremely sharp. In fact, for extremely small objects, you may need to automate the process like Shapespeare did in this great Instructable.

If your object is large: if you really want to tackle scanning a large object, there are a few specific strategies that will help make this easier, and I will address some of these later in this lesson. A lot of people also use camera equipped drones to capture landscapes or buildings. To learn more about how capturing landforms with photogrammetry from the air check out this awesome instructable by moon_goose.

If your object is moving: it is impossible to scan objects that are actually in motion, but if you want to scan something like a human who has the potential to stand still, I will talk about strategies for this in the section on Scanning the Human Body.

Lighting a Rotating Object

No matter how you are going to shoot your object, lighting is key. Low light or intense contrast will confuse the software, so strong diffused light works best. When you are shooting by keeping your camera still and rotating your object, you only need to light the part of the object that is facing your camera in any given shot. But you also need to make sure you are not casting light on your backdrop in a way that creates odd shadows or highlights. The background in these types of shots needs to be perfectly featureless or it will confuse the photogrammetry software.

To get really good results every time with this method, you will usually need to create your own lighting set-up. It can take anywhere from 1-3 diffused lighting sources to effectively light your object. There are a lot of options for this, but you can create an easy and fairly cheap one by following the instructions in audreyobscura's Photography Class.

Here's what you'll need:

2 or 3 clip lights

2 or 3 100W LED bulbs

2 or 3 white shower caps for diffusion

Shine one of these lights on either side of your object from the front, adjusting them so they cast a diffused light with a perfectly even background. You may need an additional light shining down from above to catch the top of your object. You can also use a ring light that fits around your camera lens and shines on your object from the front. Just be sure you aren't casting any weird shadows as your object rotates. If you are using a white sweep you usually wand to shine a lot of light on the background, if you are using a black sweep, keep light on the background to a minimum.

Shooting a Rotating Object

Once you have your object prepared and fixtured, place it on our turntable in front of your sweep and set up your lights so you are lighting the front of your object and creating featureless background.

For either shooting method, what you want to do is capture a series of overlapping photos all the way around your object at several angles. In order for photogrammetry software to reconstruct any point on your object, that point needs to be visible in at least 2 photos, so you need to shoot a lot of photos to capture an object well, anywhere from 20-250 depending on the size and complexity of your object. If you are shooting a very complex object you might need to shoot three or four rows of photos all around the object and some vertical rows from top to bottom. For a simpler object you might only need two rows total.

Set up your camera on a tripod in front of your object at an angle that you think will capture some important details. Make sure your object is filling up most of your frame, but not being cropped anywhere. Remember you are going to be spinning your object, so if it's an odd shape the framing could change as it rotates.

If you are shooting with a camera that allows you to adjust the settings, and you know how to use them, there are a few things you can do to optimize your images. You want to get as much of our object as possible in focus in every shot, therefore you want to shoot with a long depth of field. To do this, you need to set your F-stop to a high number, F8 is usually a good choice. A high F-stop means the aperture of your camera is smaller, letting in less light (confusing, I know). The less light you are letting in, the darker your photos will be, so you may need to proportionally slow your shutter speed to increase the brightness of your photos.

As you can see, it's a bit of a balancing at to get the right exposure. If your camera has an 'aperture priority' setting, that can be a good one to use, instead of full manual. This setting lets you set the desired F-stop, and then adjusts the rest of the camera settings accordingly.

Once you have everything set up, it's time to capture your object. Shoot one photo, then rotate your object very slightly on the turntable, about 5-15 degrees, and shoot another photo. Keep doing this all the way around until you are back to where you started. Make sure you are moving your hand fully out of the way for each photo so you don't create shadows, and watch for changes in lighting as you shoot.

https://player.vimeo.com/video/213901856?title=0&byline=0&portrait=0

Next, move your camera on your tripod to a higher or lower angle and repeat the same process. You need to capture every area of the object, especially any crevices, overhangs or details. Sometimes you also need to shoot a few vertical rows to get the bottom and top of the object. If your object has a lot of really fine textural details that you want to capture, you can also shoot some very close up detail shots to capture those.

Lighting for Shooting Around an Object

If you are shooting by moving around an object, a lot of the same lighting rules apply. You always want diffuse even light, but this time you need the light to be even ***all the way*** around your object, which can be trickier to achieve.

With this type of shooting, working outside on an overcast day is particularly ideal, and more feasible since you don't need a blank backdrop.

If you need to shoot indoors, it is sometimes possible to find a good existing lighting situation. Look for places with bright even light and avoid rooms with windows. Having in a bright window appear in the background of some shots can change the exposure of your object and confuse the software. Places like grocery stores and some well-lit office buildings will sometimes have just the right kind of light, but a lot of indoor areas will be too dim, or have light that is too directional.

If you decide to use additional lights for shooting indoors, you will need at least 3, and sometimes 4, diffused lighting sources that you can use to strategically light ***all sides*** of your object evenly at once. The diffused clip lights from audreyobscura's Photography Class are again very useful here.

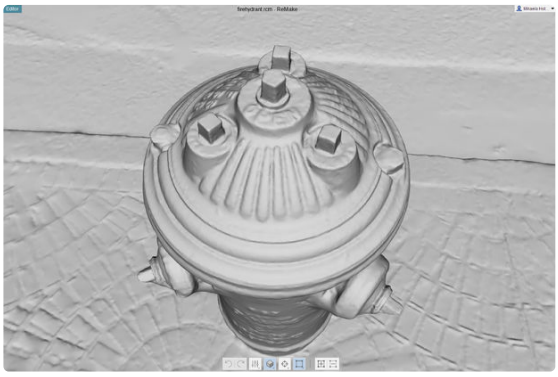
Your lights should be set up around your object so they cast an even light with minimal shadows. Try to position them close enough to shine as much light as possible one the object, but far away enough that they won't appear in your shots. This is hard to achieve,

which is part of why I don't prefer this shooting method. It's almost impossible for the lights to not end up in some of your shots. It's not the end of the world if they do, but is not ideal.

Shooting Around an Object

If you can, it's usually helpful put what you are shooting up on a stool or pedestal in the center of an open space to elevate it to a comfortable level for photos, which also makes it easy to walk around. Make sure you are shooting in a location where there is nothing moving in the background, as this will confuse the software. Also avoid places with a lot of shiny or reflective objects in the background.

It helps to have a distinct visual pattern around your subject. This provides more reference points for the software. It also means you'll end up with some extra bits under your 3D model, but these can be erased in the editing process. If you can find an object outdoors with a pattern around the base, it will be a huge help. The pattern of bricks under this fire hydrant really made it turn out well.



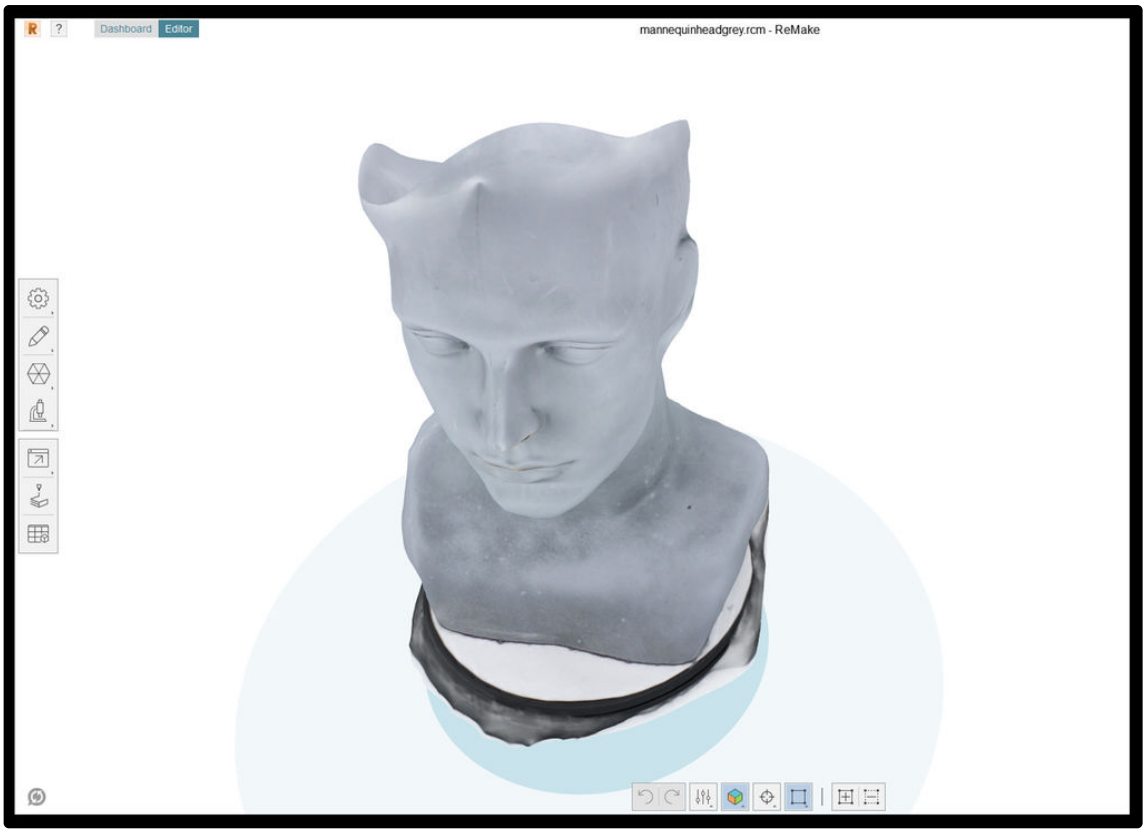
Or if you are indoors, just laying a piece of newspaper on your base or placing some small objects around it is enough, but make sure whatever you're using isn't shiny or reflective... I'm sure you're getting the point by now that shiny and reflective is the enemy of photogrammetry :)

You can try shooting your object either with or without a tripod. A tripod will ensure that all the photos in each rotation around your object are taken at the same angle. It will also help make your images sharp, especially if the light is low, but shooting with a tripod is also more time consuming so if you have bright enough light you might want to try shooting freehand first. Using monopod is a good compromise here.

The same camera setting suggestions apply here as for the other shooting method, and it can be especially useful here to have your camera on a manual setting so your exposure doesn't change as you move around your object. If you are shooting without a tripod, however be careful because a slow shutter speed, anything below about 60, can make your photos blurry, which is why lights and a tripod can help.

Choose an angle and start shooting by moving around your object, moving about 5-15 degrees for each new photo. Try to hold your camera as steady as possible and maintain the same angle all the way around until you are back to where you started. Then choose a higher or lower angle and repeat the same process.

Shoot as many rows as you think you need to capture your object, and make sure you get all the way over the very top. I find that it's easy to miss this part of the object which can result in scans like this:



Tips for Scanning a Human

One thing that a lot of people want to do when they start out with 3D scanning is scan themselves or someone else. This is definitely a challenge, but it's not impossible. For one thing, humans are not static, so it's difficult to take all the photos you need for photogrammetry without your subject moving. Also, people are big, so you can't just put them on your little rotating turntable and call it a day.

The absolute best way to capture a person with photogrammetry is to create a multi-camera rig, so that images of the person are captured from all angles at the same moment, eliminating the problem of movement. Mparker07 as a great Instructable that shows how to create your own rig like this, the only problem is, it costs quite a bit of money to set up.

The cheapest way is to try shooting around your subject in even bright light like you did with the smaller objects. I've seen scans like this turn out quite well, you just need a really patient subject who is good at standing still. We were joking the other day that someday people will look back on 3D scanning today the same way we think of photo portraits from the 1800s: "Can you believe you had to stand still for so long just to be 3D scanned??!" :)

If you want to try the 'rotate the object' method of scanning a human, you will need an automated turntable, a large white or black sweep and some very good lights. You can put your camera on burst shooting mode with a very fast shutter speed and just shoot continually as your subject rotates. In my experience however, this method is more trouble than it's worth when scanning people, and doesn't get better results than the 'shoot around' method.

You can also check out this Instructable by Amy Karl for more info about human scanning.

In the Next Lesson...

Once you have a good set of photos of the object you want to scan the hard part is over. In the next lesson I'll show you when and how to edit the photos you've shot, and then walk you through the process of uploading them to ReCap Photo where they will magically be transformed into 3D models!

LESSON 4: TURNING YOUR PHOTOS INTO A 3D MODEL

The real magic of 3D scanning mostly happens in the mysterious world of algorithms that make programs like ReCap Photo function, so once you have a good set of photos, a lot of the work is out of your hands.

In this lesson I'll show you how to make a few simple edits to optimize your photos for 3D scanning. Then we'll upload your photos so they can magically be transformed from 2 to 3 dimensions! Once your model has been created, I'll show you how to view and inspect it in the ReCap Photo editing environment.

Editing Your Photos

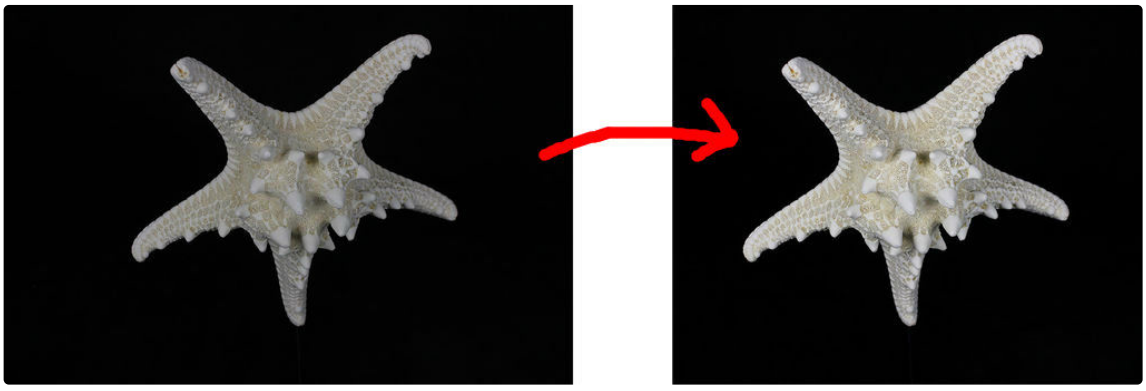
Once you think you've shot enough photos to completely capture your object, upload them onto your computer and look through them. You may have shot some photos that you don't want to keep. Some might be blurry, or the exposure might be different than the rest. It's best to eliminate those photos from the set because they can mess up your reconstruction.

If you were shooting around your object and there are one or two photos with something in the background that was moving, it shouldn't effect your reconstruction too much, but if there are a lot of shots like this, you might want to try shooting again.

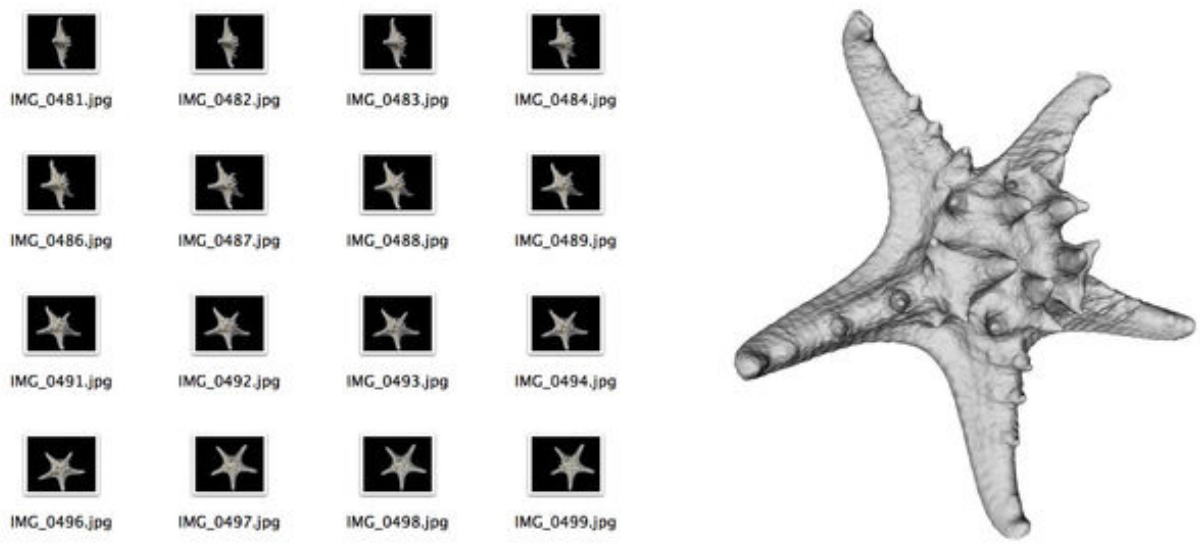
You generally don't want to edit individual photos at all, but if, for example, all of your photos look a bit too dark once you've uploaded them, you can try increasing the brightness on all of them equally. It's easy to do this in programs like Adobe Bridge or Lightroom, or even iPhoto.

https://player.vimeo.com/video/207870823?title=0&byline=0&portrait=0

If I shot on a white background, I will often lighten the whites in the photo to make the background as blank as possible. And similarly if I shot on a black background, I will darken the blacks. I usually crop my photos as close as I can without cropping the object, and I sometimes turn up the clarity a little to intensify the details.



If you were using the rotating object method, and some of your photos are showing something other than the white or black background, like part of your stand for example, you might want to mask this area away with the same color as the background.



Uploading Your Photos to ReCap Photo

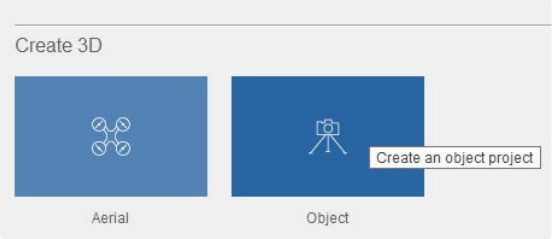
Once you've downloaded your photo set onto your computer and done any necessary editing, it's time to upload your photos to ReCap and create a model!

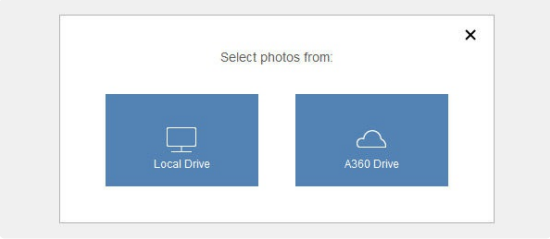
Please note: The video below, and all the videos in this class, were created when ReCap Photo was still called ReMake, but the interface is nearly identical. In the text below the video I address some of the small differences.

https://player.vimeo.com/video/207870848?title=0&byline=0&portrait=0

The only real difference between the ReMake and ReCap Photo dashboards, is that there are now two options under Create 3D: Ariel allows you to create scans from ariel drone footage and Object does what the Photos button did in ReMake. We won't be using the Ariel feature in this class, but I encourage you to experiment with it if you have a drone!

To upload your photos, click on the Object icon under Create 3D. ReCap Photo only creates meshes in the cloud, so there is not option here for 'Online' or 'Offline' as there was in ReMake.

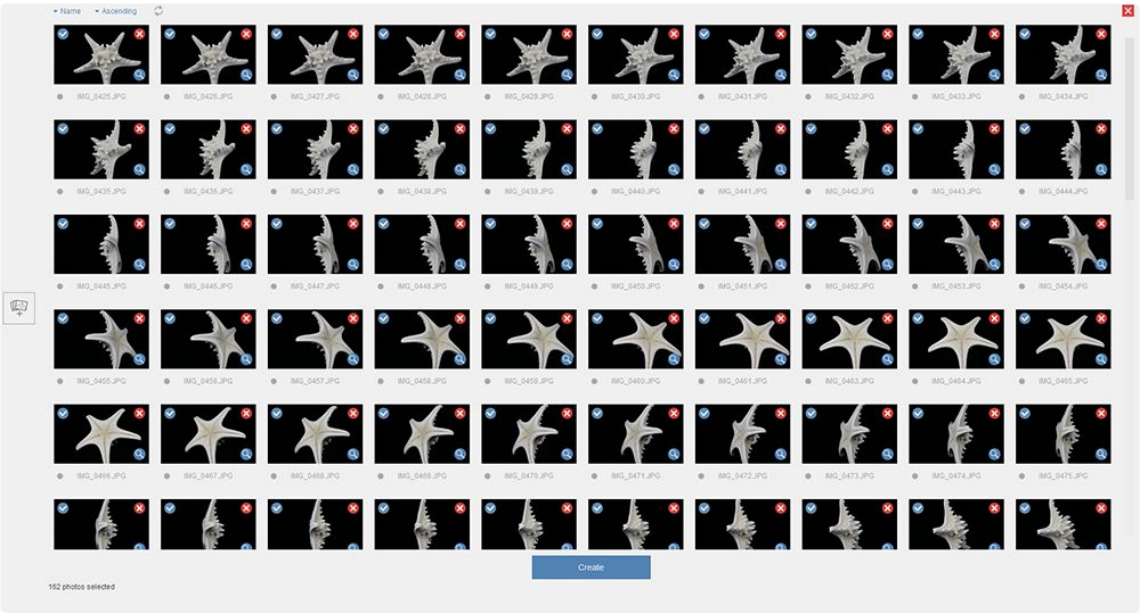




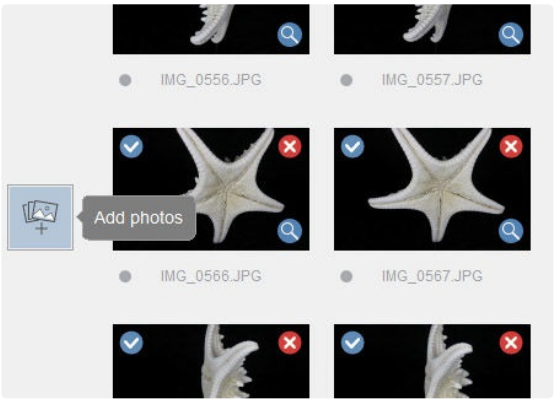
You'll be given an option to select photos from either your Local Drive or Autodesk Cloud drive. My photos are on my computer, so I'm selecting Local Drive.

Browse to the folder with the photos of your object, select all of them and click open. All the photos you selected will show up in a window. They will always be shown in landscape even if your photo files are oriented in portrait. If there are any photos you forgot to delete

from the set, you have another opportunity to do that now by clicking on the red x in the top left, or deselecting the photos by clicking on the blue check mark in the top right.

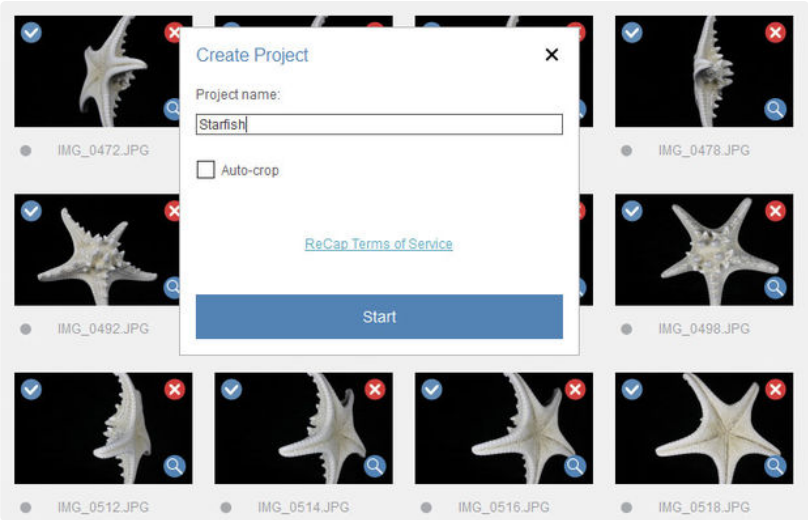


You can also click on the magnifying glass in the bottom right to see a large version of the photo. On the bottom of the screen you can see how many photos are in your set, to add more photos, click on the 'Add Photos' button on the left. Different versions of the software give you different numbers of photo options. The free trial and subscription versions let you process as many as 1,000 photos, while the education version only lets you process 100 photos.

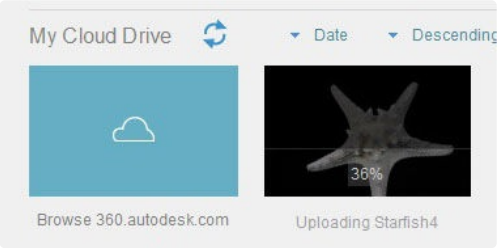


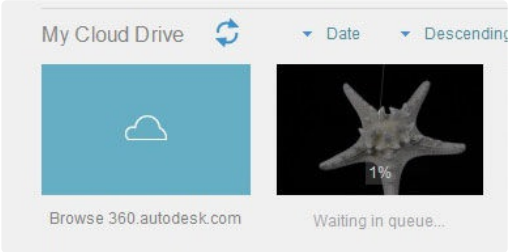
Once you have all the photos you want, hit the ‘Create’ button at the bottom of the page to upload your photos to the cloud. In the dialog box that pops up, enter a name for your file.

You will also see an option that says for 'Auto-Crop'. If you shot using the 'shoot around the object' strategy, auto crop will help prevent objects from in the background from being reconstructed. Once you’ve made this selection, hit 'Start' to start creating your model.



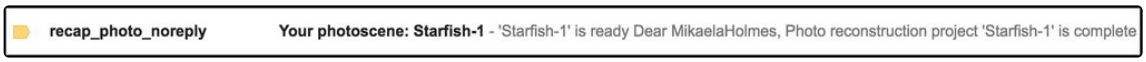
You'll be taken back to the Dashboard screen and you'll see a thumbnail of your project under 'My Cloud Drive' at the bottom of the screen that shows the upload progress of your photos. Don't click away from this screen until the upload is complete and has switched to 'Waiting in Queue'. Once it has processed at least 1% in the queue, you can click away from this screen, but if you click away before that, your job will stop processing.





Downloading Your Model

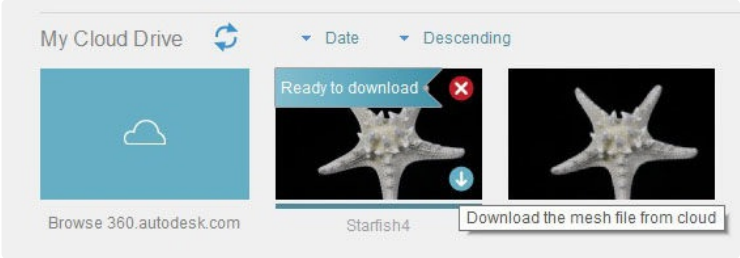
Once a model has been created from your photos, you'll get an email telling you that your file is ready.



I get really excited by these emails because now I get to see if my scan was successful!

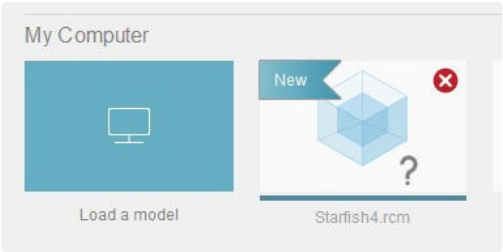
https://player.vimeo.com/video/207873268?title=0&byline=0&portrait=0

Back on the ReCap Photo Dashboard, you will now see a thumbnail of your project under 'My Cloud Drive' that says 'Ready to download'. If you hover over the thumbnail you will see a blue download symbol in the bottom right hand corner.



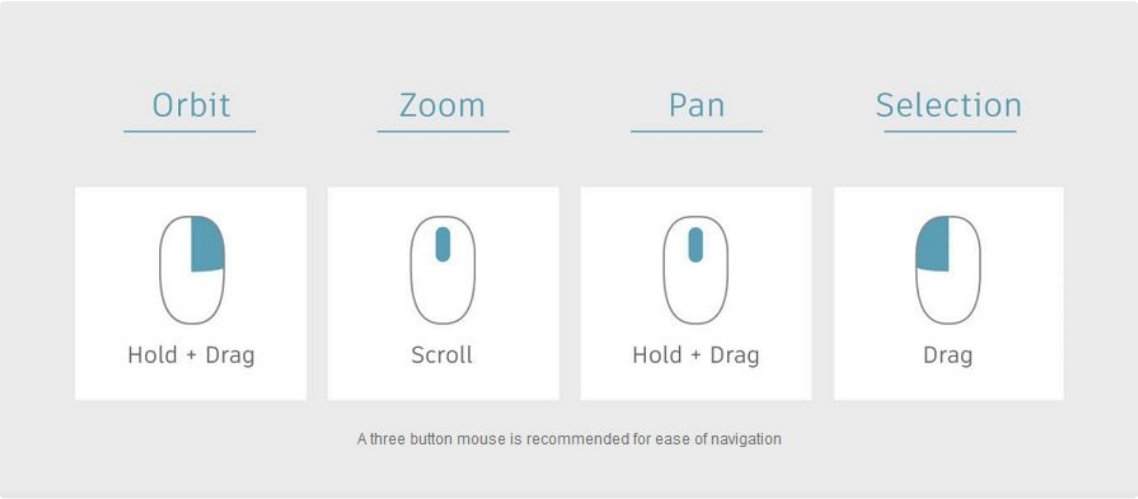
Click on it and a dialog box will open asking you where you want to save the file on your computer. Browse to the location you want and save the file. Once you have saved a file from ReCap in a specific location on your computer, moving it will remove it from the ReCap Dashboard, so it's best to save it in the place you want it to stay.

Once it is downloaded, it will appear on the Dashboard under 'My Computer' where you can click on it to open it in the 'Editor' environment.



Viewing Your Model

Hopefully, when you open your model, you will see a 3D representation of the object you shot, not an unrecognizable blob. However, if at first you do see an unrecognizable blob, don't panic yet. Often when your 3D model is compiled, objects from the background will end up being partially reconstructed as well. Once you zoom in and move your model around, you will be able to see whether you have captured a good scan of your object itself. So let's learn how to use the basic mouse controls to move around your model.



To orbit your model, hold down your right mouse button and drag your mouse.

To zoom in and out on your model, use the scroll wheel. Where your cursor is placed when you start zooming will determine the direction of your zoom, so if you want to zoom in on the center of your model… start zooming with your cursor in the center of your model.

To pan back and forth across the screen, hold the scroll wheel down and drag your mouse.

If moving around your model seems difficult or weird at first or if your model is visibly upside down, or oriented oddly, you might need to set it upright (once again, the interface has some slight visual differences now that it's called ReCap Photo, but everything fundamentally works the same way).

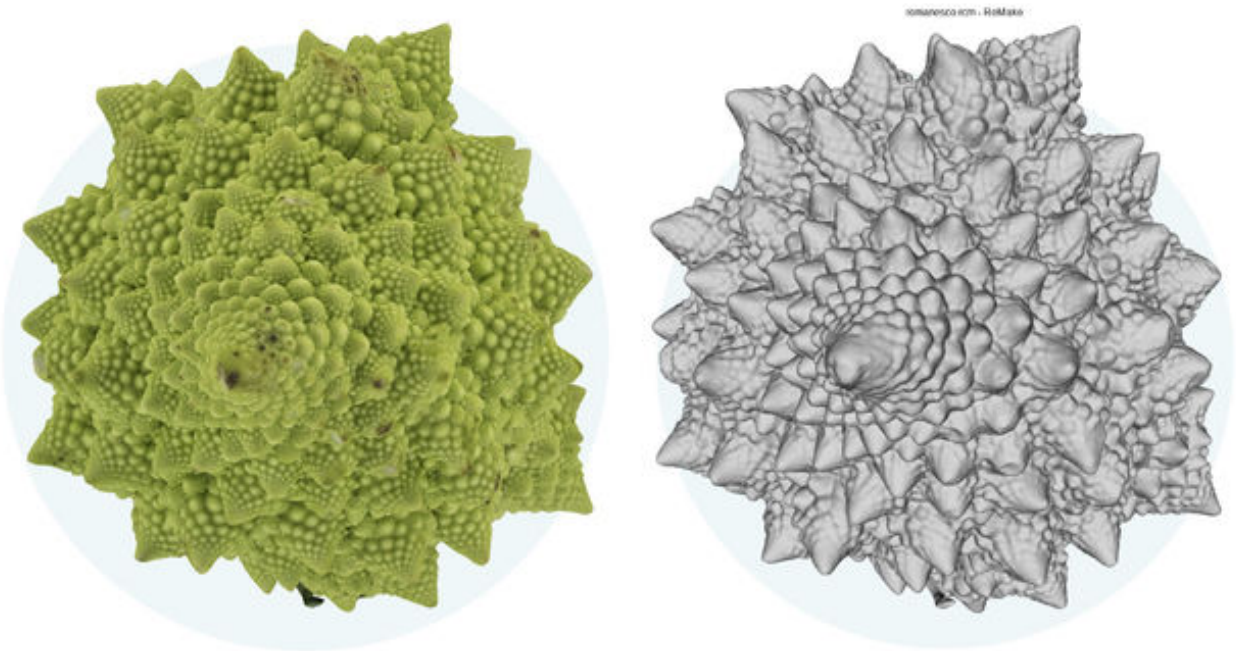
https://player.vimeo.com/video/207870889?title=0&byline=0&portrait=0

To do this, click on the gear wheel icon at the top of the left-hand toolbar and select the 'Set scene upright' tool which looks like an arrow with a circle under it.

A ring will appear around your object, this is a gizmo that will let you rotate the orientation of your model when you click and turn it with your left mouse button.

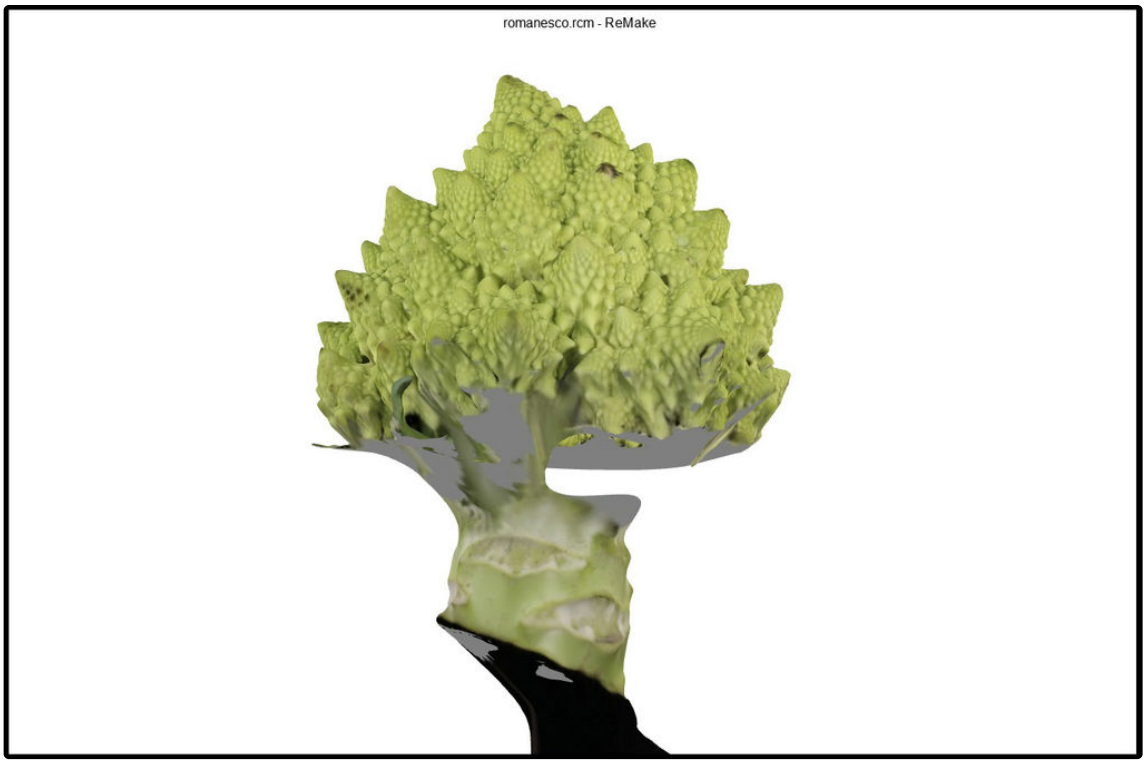
You can also use your right mouse button to click on the model and move it freely, or use the orientation shortcut buttons in the dialog box. Move your model around until it is right side up and centered, then click 'Apply'. Now when you orbit your model should behave

more naturally.



Inspecting Your Model

It's usually fairly easy to tell immediately if there are any big problems with your model. For example, this romanesco has a giant hole in the underside and isn't color mapped in some places.



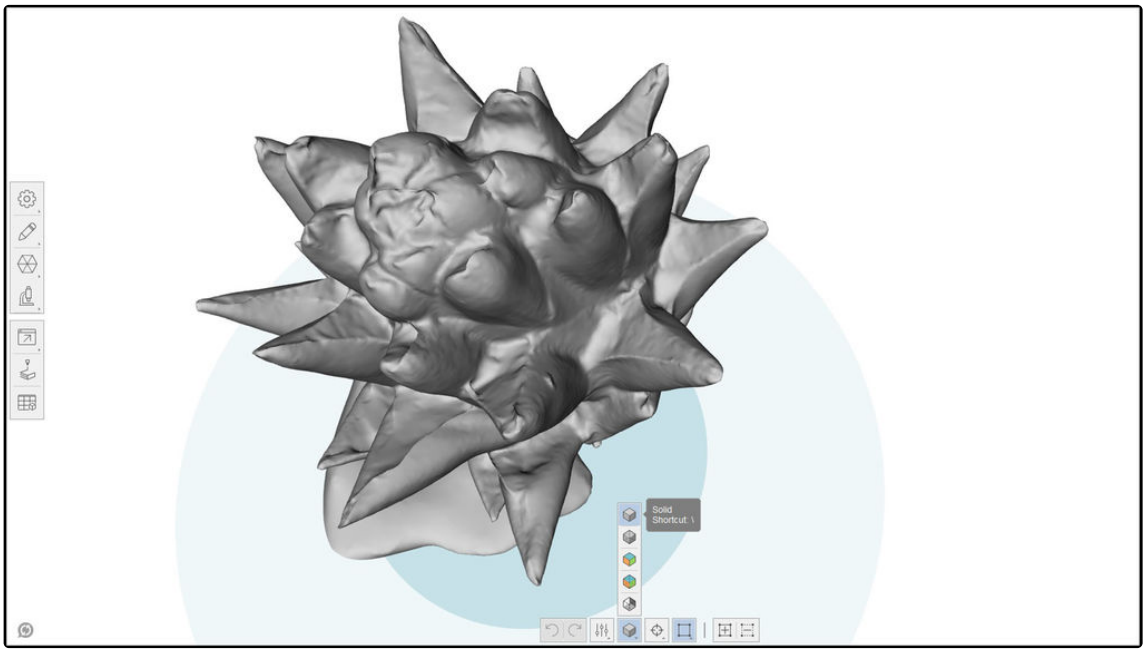
It looks like the top was actually captured pretty well, so if you only wanted to use that part, this model might still work for you. However, some flaws are a little harder to see at first glance, and to check for these you need to change the way you are viewing your model.

https://player.vimeo.com/video/207873800?title=0&byline=0&portrait=0

When you first open your model, it will be shown to you with the color mapping, or 'texture' turned on. (I personally find the term 'texture' to be misleading because this colored surface is only visual not geometric). The model almost always looks best with the color layer turned on, and if you are intending to use it in a gaming or online environment (or print it with a color 3D printer) this is great, but if you are planning to use the actual structure of the object for 3D printing or some other physical application, the color mapping actually hides some structural details.

To actually tell how accurately your scan has captured the shape of your object, you need to turn off the color layer. On the bottom menu, click on the colored cube and you will see a menu with visualization options. Each of these will let you inspect your object in a different way.

The greyscale square at the top will put your object in 'solid' mode, showing you just the shape, not the color. This is the best mode to use for a quick inspection of the quality of your scan.



As you can see, when you switch to solid mode, some details of your object that are represented in color will disappear, and sometimes other flaws may appear that were hidden by the color. In the case of this artichoke, the concave areas of the leaves were not captured as part of the structure, even though you can see them in the color map.

Similarly in this mannequin head, though the color mapped version looks smooth and the features are defined, the solid model is oddly lumpy and the features are a little blurred.

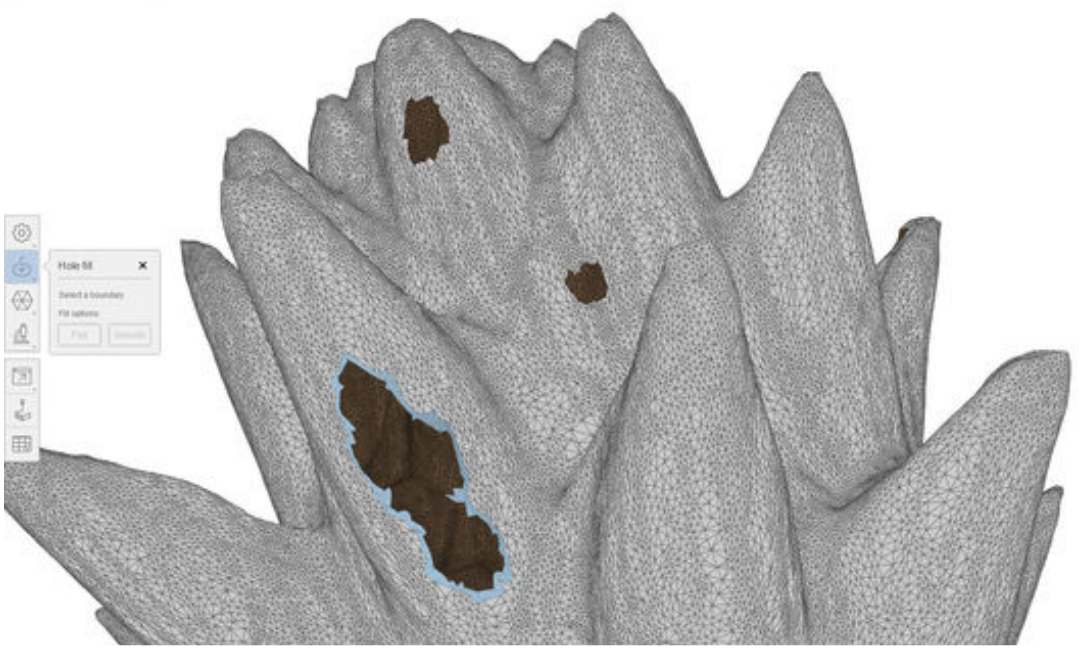
Some of these imperfections can be fixed by using the smoothing and sculpting tools we will learn in the next lesson, but if your model really looks too far away from the original object, you might want to try shooting a new set of photos. In this case I think the artichoke is probably as good as I'm going to get, but the head needs to be re-shot. Repairing and fixing models can be a very time consuming and frustrating process, so the more accurate your original scan is, the better.

In the Next Lesson...

Now that you've created a 3D model from your photos, let's learn how to fix any flaws that might have occurred during the reconstruction process. In the next lesson I'll show you how to use the tools in the ReCap Photo editing environment to clean up your model and perform some simple alterations that will make it ready to use.

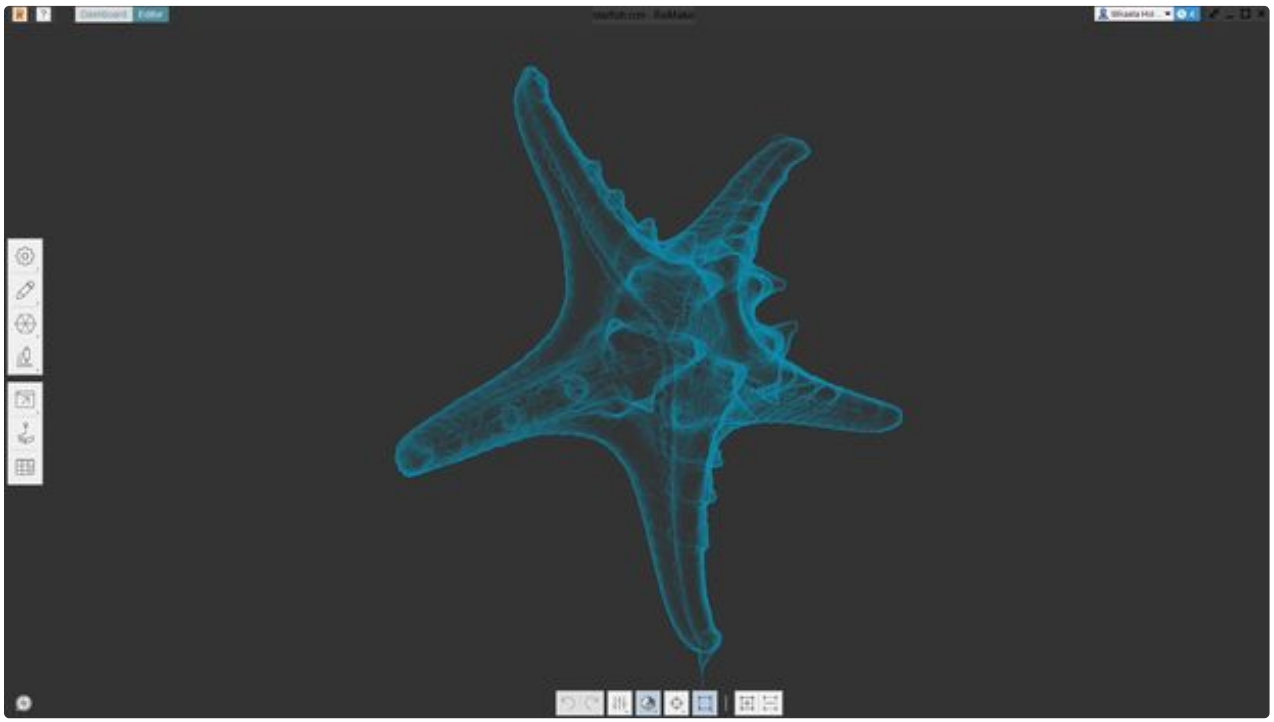
In the meantime, feel free to share an screenshot of the 3D model you've created below! Even if the results you are getting aren't great yet, feel free to share and ask questions :)

LESSON 5: CLEANING UP YOUR 3D MODEL



It's extremely rare, if not impossible, to end up with a 3D model that has no flaws. Mostly these flaws will come from the point where your object was fixtured, or where it touched the ground, but sometimes there will be other small areas that didn't reconstruct well for some reason. Some flaws are visual and others will present more fundamental structural problems if you plan to 3D print your model. Most flaws can be cleaned up pretty easily, and some are bit more of a challenge. Fortunately ReCap Photo has a well designed set of tools for fixing these problems, that are also easy to learn.

In this lesson, I'll give you an overview of all the toolbars and then show you how to use some specific tools for the kind of model repair you'll be doing most often.

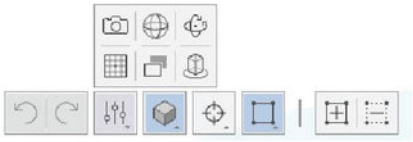
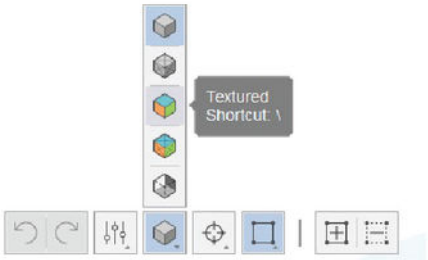
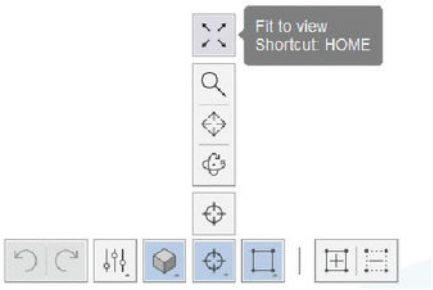
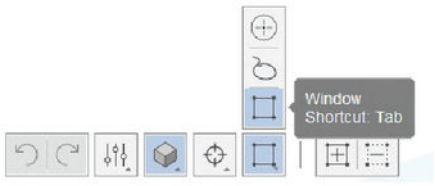


Tools in the ReCap Photo Editing Environment

In the ReCap Photo Editor you will find three main toolbars that contain all the functions you need to view and edit your model. Clicking on most of the icons will bring up a menu of further options in that category. I'll give you a basic overview of what's in each toolbar, and in the next section I'll show you which workflows you'll use to most often to clean up your models.

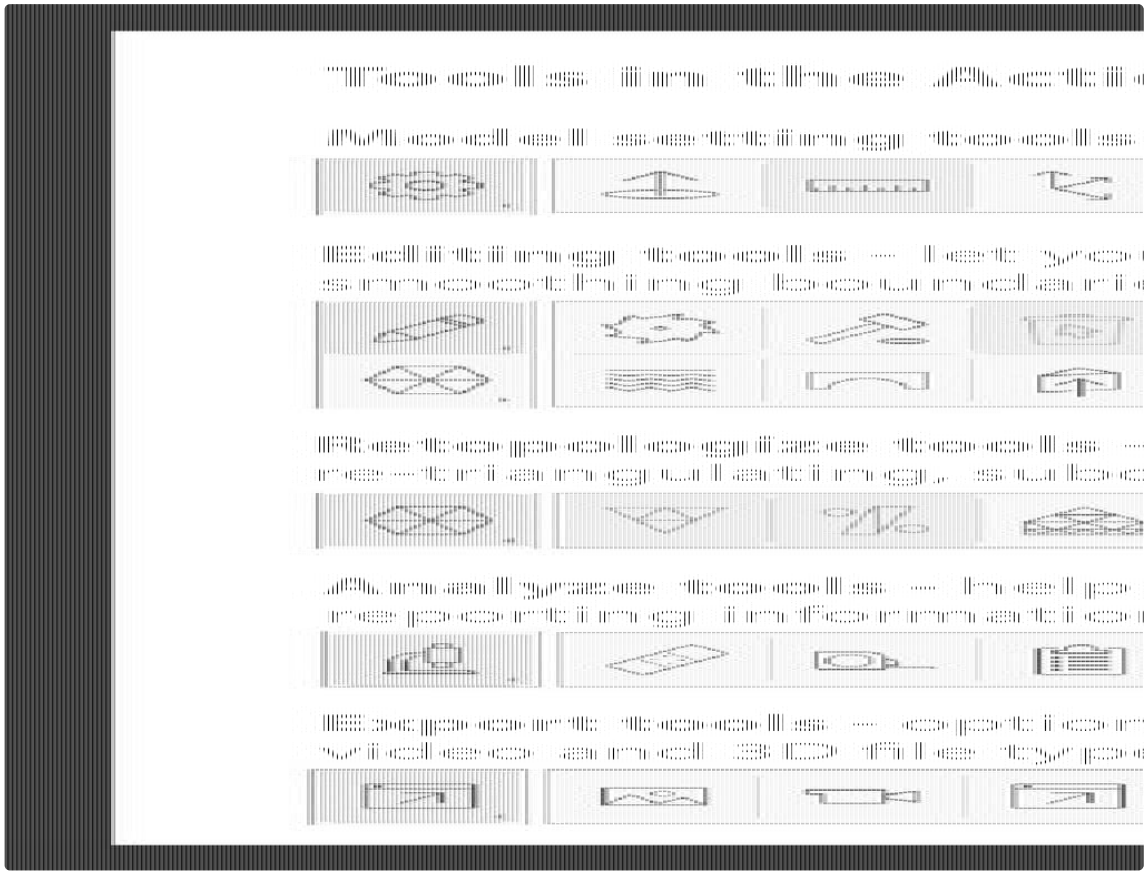
The Navigation Bar is the line of icons at the bottom of the screen.

Here you can access from left to right:

	**Undo and re-do** - clicking on these will undo and re-do your editing actions
	**Environment modes** - options for the background of your workspace or the perspective with witch you are viewing your model
	**Model display controls** - as discussed in the last lesson, this is where you can change the style of your model from color mapped, to mesh, to solid to x-ray and a few combinations
	**Navigation** - this icon contains most of the same navigation options you have when using your mouse controls, plus a button that brings you back to a "home" view
	**Selection** - contains options for how you select parts of your model: paintbrush, lasso or window. The four icons to the right of Selection are options you use while you are selecting that let you add to or subtract from your selection, invert or isolate your selection

The Action Panel is the vertical menu on the left hand side of the screen. Here you will find from top to bottom:

Clicking on each icon opens a menu of further tools that will let you perform certain types of edits to your model.



Deleting Parts of Your Model

As I mentioned in the last lesson, when your model is created, there will sometimes be some extra bits around the edges or particularly the base. Deleting these pieces is the often the first part of the model clean-up process.

https://player.vimeo.com/video/209147346?title=0&byline=0&portrait=0

The simplest way to delete is to use the slice tool, which looks like a little saw blade in the Tools menu. Clicking on this tool will give you a flat horizontal plane with an inner and outer circle. The outer circle lets you move the plane up and down and the inner circle tilts

the plane at an angle. Clicking apply will delete everything below the plane. You can also switch which side of the plane gets deleted by clicking on the little black and white square in the dialog box, and you can choose to have the hole created by the deletion left open, or filled.

Another way to delete parts of your model is to use the select and delete tools. This lets you select smaller or more oddly shaped areas of the model.

https://player.vimeo.com/video/209146219?title=0&byline=0&portrait=0

For example, if you needed to delete a small isolated piece of your model, click on the select tool in the Navigation Bar on the bottom of the screen and pick your selection type. For this, the bottom icon, the **window selection**, will work best. Click and drag to select this piece then release.

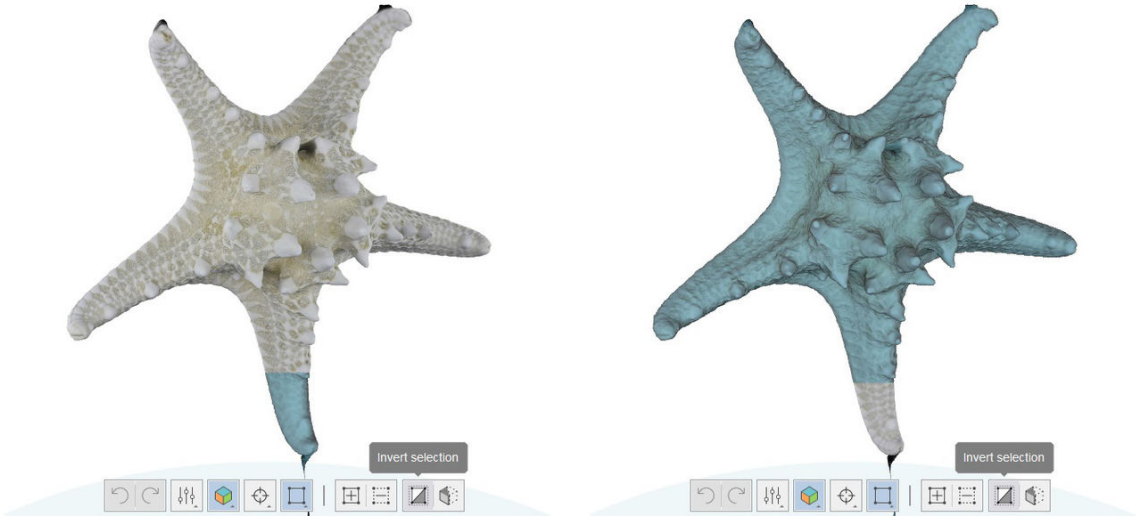
To delete, click on the Tools icon in the Action Panel on the left and select the **delete** icon which looks like a trash can. The piece you selected will be deleted. Notice that when you are using the window selection mode, you are selecting all the way through your object, not just the visible surface.

If you wanted to delete a more oddly shaped area of your model, you could choose the **lasso selection tool**. This tool lets you draw any shaped area to select. With this tool you are also selecting all the way through your object, not just the visible surface, so when you hit delete, everything in the area you selected will vanish.

If you want to select more than one piece to be deleted at once, you can use the **add to selection** button on the right of the Navigation Bar. If instead you want to remove something from the selection, use the **subtract from selection** button.

If you ever want to undo any action, just click on the undo button.

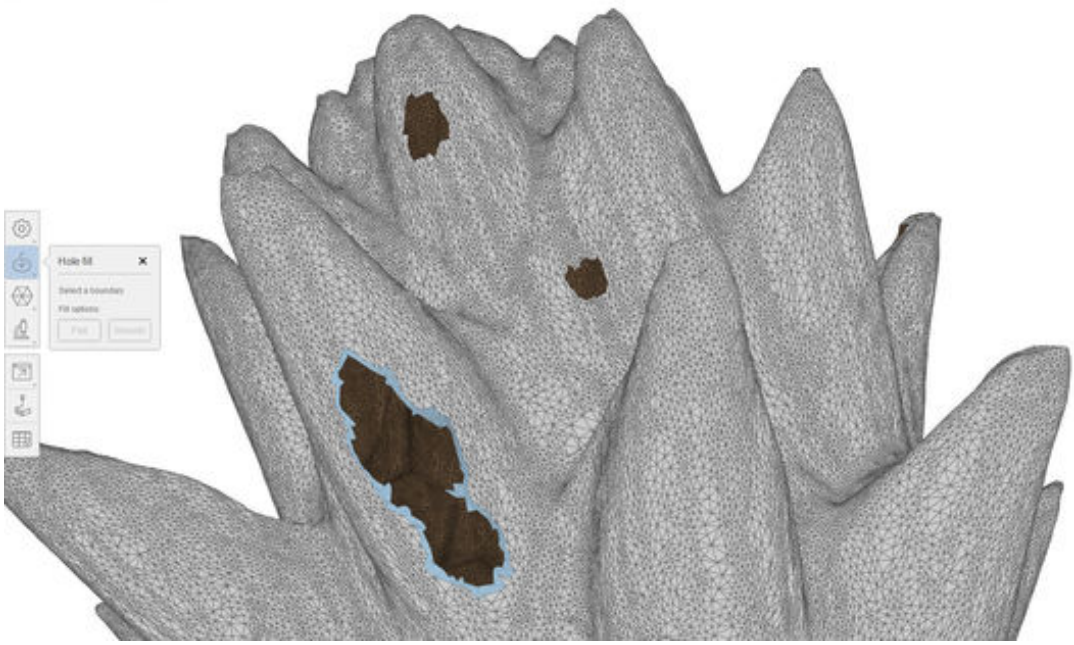
It can sometimes be easier to select what you don't want to delete. In this case, use a selection tool to grab everything but your intended selection, then hit the **invert selection** button to select the opposite.



If, instead of deleting part of your model, you would just like to hide it so you can see the rest of the model better, you can use the **isolate selection** function. Select what you want to keep visible, hit the isolate selection button, and everything else will be temporarily hidden.

If you want to just select part of the surface of your model, instead of selecting all the way through, you use the **brush selection** tool. This tool acts like a paintbrush, letting you select very small areas on the surface of your model. You can also alter the size of your brush in this tool.

If you delete a selection made with the brush selection tool, it will create a hole in the surface of your mesh, and we'll talk about how to fix holes next.



Filling Holes

Sometimes your deleting process will create holes in your mesh, and sometimes there will be pre-existing holes that were glitches from the reconstruction process, either way, they often need to be repaired, and there are a few ways to do this.

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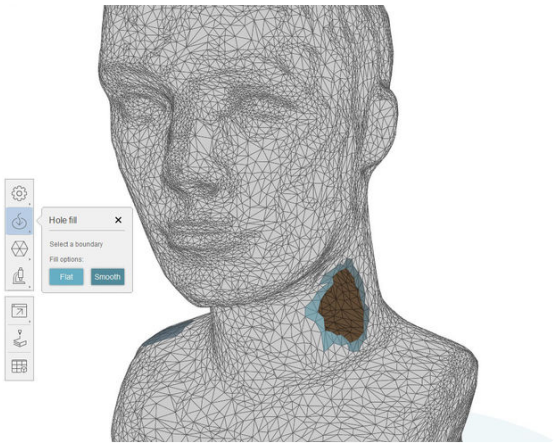
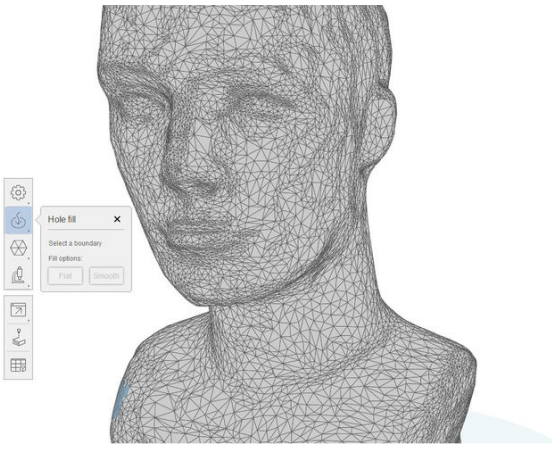
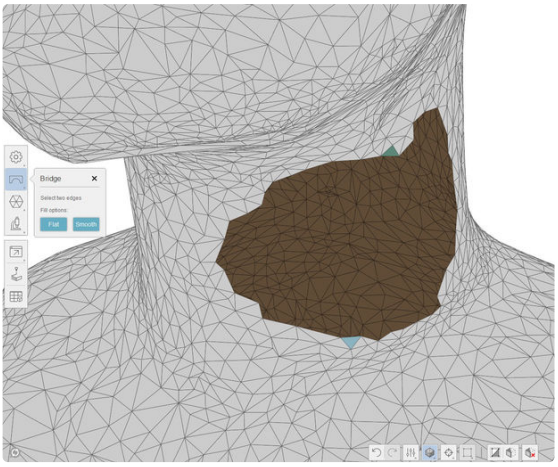
As you saw in the last section, the slice tool will automatically fill in holes created by slicing if you want it to. But if you left your holes unfilled, you can use the **fill holes** tool to close them easily.

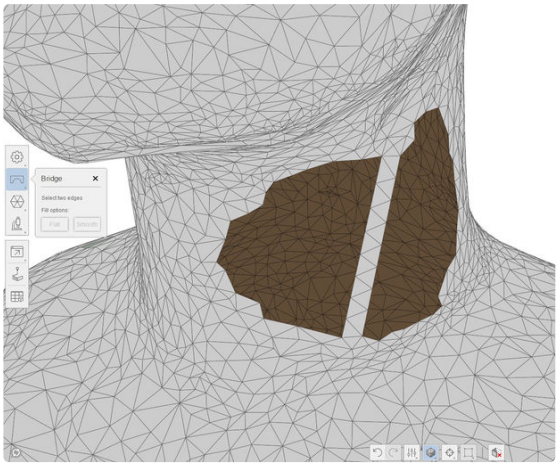
This tool is under the Tools icon and looks like an arrow diving into a hole. When you click on this tool, it will automatically detect all the holes in your mesh and they will be highlighted in brown. The dialog box will ask you to 'select a boundary'. If you hover close to the hole you want to fill, the edge of that hole will be highlighted and you can click to select it. Decide if you want your fill to be 'flat' or 'smooth', and click to apply. If you are filling a hole on a curved surface, 'smooth' is usually a good option. If you are filling something like, say the end of a tube, you probably want 'flat'.



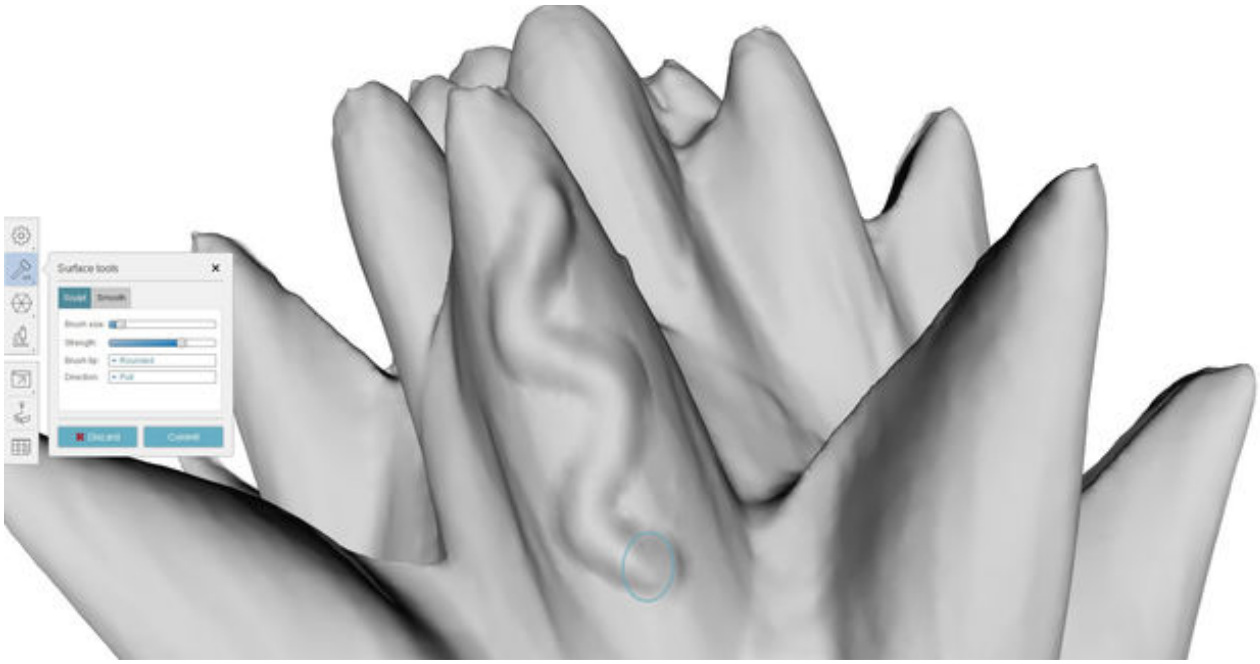


If you need to fill a large hole on a more complex surface, you can use a combination of a few tools to construct a more custom fill. Start by using the **bridge gaps** tool to divide your hole into smaller holes. When you open this tool, you will be asked to select two polygons on opposite sides of your hole that your want to create a bridge between. Once you select both points a bridge will be created.





Now you have created a separate hole on each side of the bridge, and you can fill those holes in individually with the **fill holes** tool. As you can see, using these tools in combination could let you construct some more complex features if you needed to.



Sculpting and Smoothing

Some other great tools for cleaning up your models and even adding to them are the smoothing and sculpting tools.

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To access these tools, click on Edit and then select **surface tools** which looks like a mallet. When you click on this tool it will automatically put your model into a wireframe mesh view, but you can change your view to solid if you want, which I think makes it easier to see what you are doing. The dialog box that pops up will give you the option to choose **sculpt** or **smooth**.

Smooth will help you fix areas of your model that may have acquired weird unwanted textures during reconstruction. It is a smart tool that both pushes and pulls areas of the surface you are using it on smooth away imperfections. You can choose your brush size and the strength of the smoothing by sliding the toggles. I usually start with my strength low and raise it if I need to. After you've made your adjustment, clicking 'commit' will apply the changes you just made, and 'discard' will undo them.

Sculpt is a more powerful tool that does just what the name says: lets you sculpt your model and add features or details in places where they were lost.

https://player.vimeo.com/video/210678335?title=0&byline=0&portrait=0

In sculpt mode you can choose to pull or push the surface of your model. Pulling will create raised areas, while pushing will create indents. You can also choose your brush size, the strength of your brush, and whether or not your brush is flat or rounded which will create different effects. On each specific model you will have to play around with the settings to see what works for you.

Small surface changes to your model will not affect the color texture layer, and when you make larger changes, the texture will try to stretch over these new geometries like a skin.

Sometimes this works pretty well, and other times it's a bit weird looking. To see how this is going to look, commit your changes and switch your model to textured view. If you don't like what you see, you can always undo by pressing the undo button.

Retopologizing

If you are trying to do some very delicate sculpting and you can't get the detail you want, you can try subdividing your mesh in the area you are trying to edit.

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Because the geometry of your model is defined by the polygons in the mesh surface, more polygons means the ability to define more detail. To get more polygons, put your model in mesh mode, select the area you want to edit with the brush selection tool, then click on **subdivide mesh** under Retopologize. You will see that the area you selected has been subdivided into twice as many polygons. Now try making the edits you wanted with the sculpt tool and see if you get better results.

Extruding

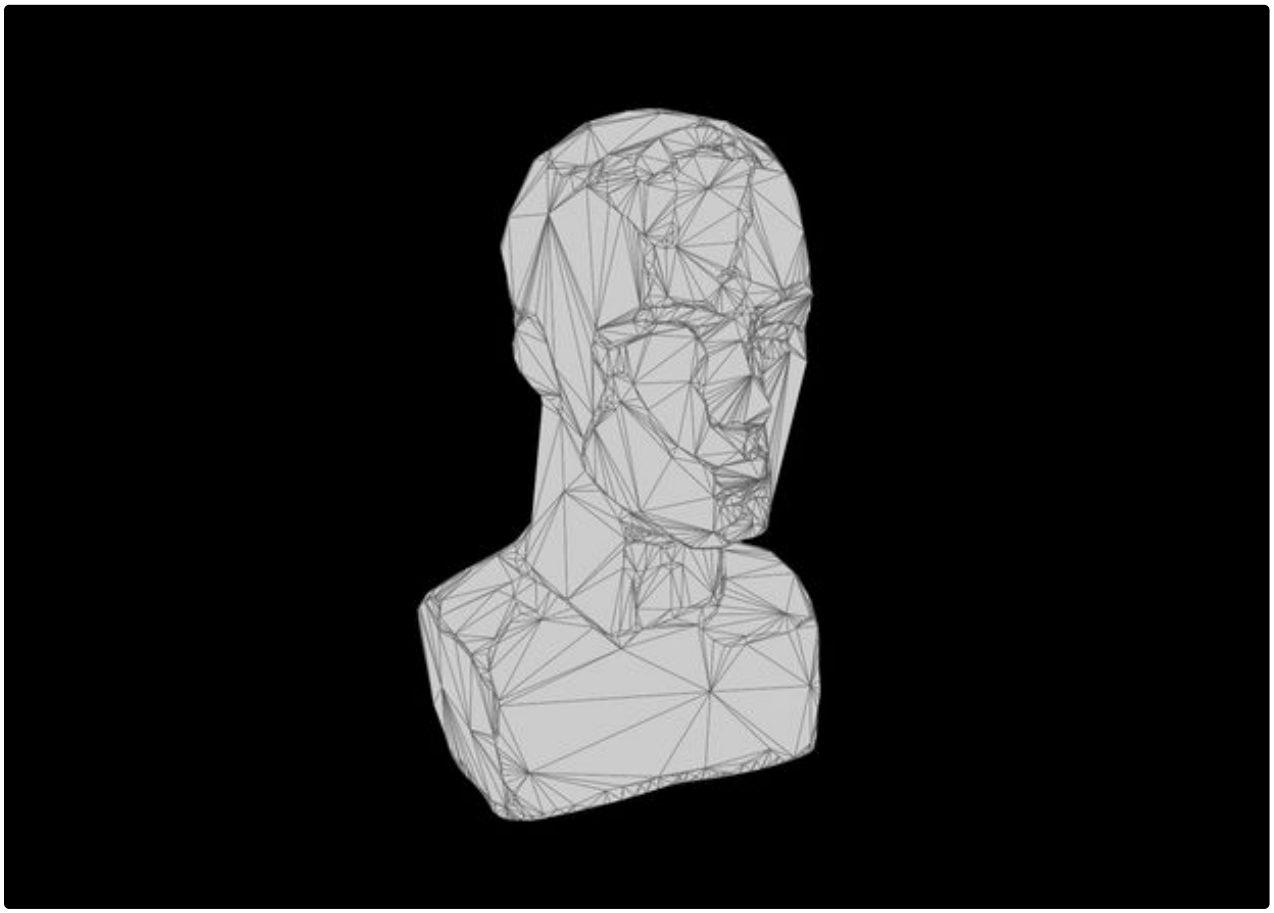
The **extrude** tool will let you add simple features to areas of your model that have been removed. Extrude is especially good for creating bases for things like statues or models of people. If you had scanned a person for example and you wanted to print them in miniature and give them a little base to stand on, you could use the slice and extrude tools to do this.

https://player.vimeo.com/video/210693914?title=0&byline=0&portrait=0

First, use the slice tool to cut off the base of the figure at the level you want, when you slice, check 'no fill'.

It can be useful to then use the **smooth boundary** tool (also under the Tools icon) to make sure your slice is as clean as possible. To do this, select the open boundary of your slice and then click 'apply'.

Now select the extrude tool, click on the open boundary again and decide if you want your extrude to be filled left unfilled. You can choose if you want to extrude 'flush to plane' or 'offset from boundary'. Flush to plane lets you use the the movable plane to choose the end point of your extrusion, and 'offset from boundary' extruded a specified distance from the sliced edge.



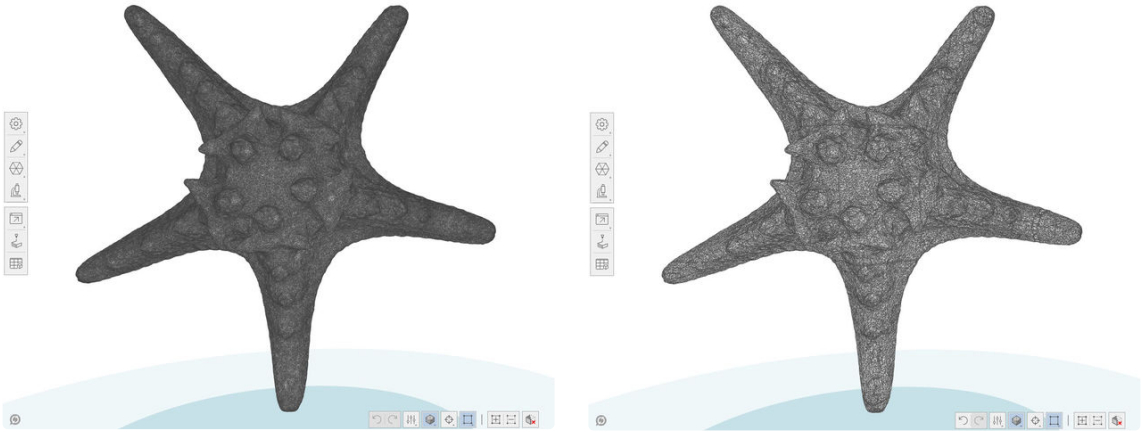
Decimating

When you have made all the edits you want to make to your model and you are ready to export it to another 3D modeling program or some other application, you will often want to reduce the complexity of your model by retopologizing the surface.

https://player.vimeo.com/video/210646727?title=0&byline=0&portrait=0

As we discussed in Lesson 2, 3D models created from photogrammetry are polygon mesh models, which means the geometry of their surfaces is represented by a large number of polygons arranged in a dense “mesh”. Meshes that come from photogrammetry and other reality capture methods sometimes have a much higher number of polygons or “polycount” than 3D models that were created in a 3D modeling program. Sometimes thousands of times more.

Models like this are often too complex for other 3D modeling programs or applications to handle, so you need to simplify them. To do this, click on the Retopologize icon and select the **decimate model** tool.



This tool lets you reduce the polygon count of your mesh without affecting the overall geometry too much. Toggle the slider to choose how much you want to decimate your mesh, then click 'decimate all'. If your mesh changes too much and you lose a lot of detail, you may want to decimate it less. If there is still plenty of detail, you can try decimating it more.

For models that are going to be used in something like gaming or VR with the color texture turned on, you can decimate them to a very low polycount because the decimation won’t affect the textured color layer and the model will still look good even when the actual geometry lacks detail.

Measuring and Scaling

Because ReCap Photo has no size reference when it compiles your photos, the size of your model is not necessarily the same as the size of your original object, and even it it was, you might want to change the size before you export.

https://player.vimeo.com/video/210692460?title=0&byline=0&portrait=0

To measure the distance between different points on your model, click on Analyze, and select **measure distance**. You can then click on two points on your model and it will tell you the distance between them. Keep in mind it is measuring in 3 dimensions.

To scale your model to the size you actually want it, click on Model settings and select set **scale and units**. This will put your object inside a box that shows its X, Y and Z dimensions. With 'percentage' checked, you can scale your object by a certain percent, and checking 'value' will let you enter a specific value for X, Y or Z. Or you can select two points on the model like you did with the measure tool and enter a target value for that distance.

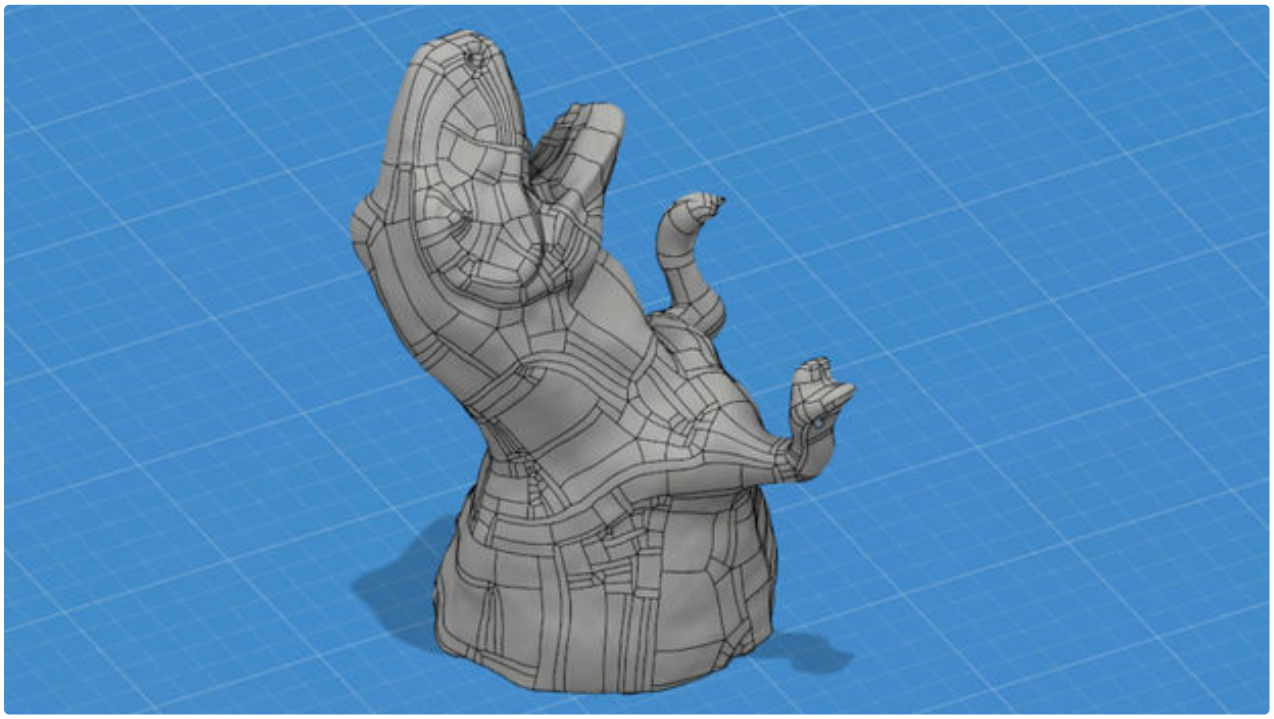
Once you hit 'set' your model will be re-sized according to your new values.

In the Next Lesson...

Now that you have a nice clean, edited model, what are you going to do with it? In the next lesson we'll learn some useful tools for exporting your model to use in different applications, and explore a workflow that will give you more advanced 3D modeling options in Fusion 360.

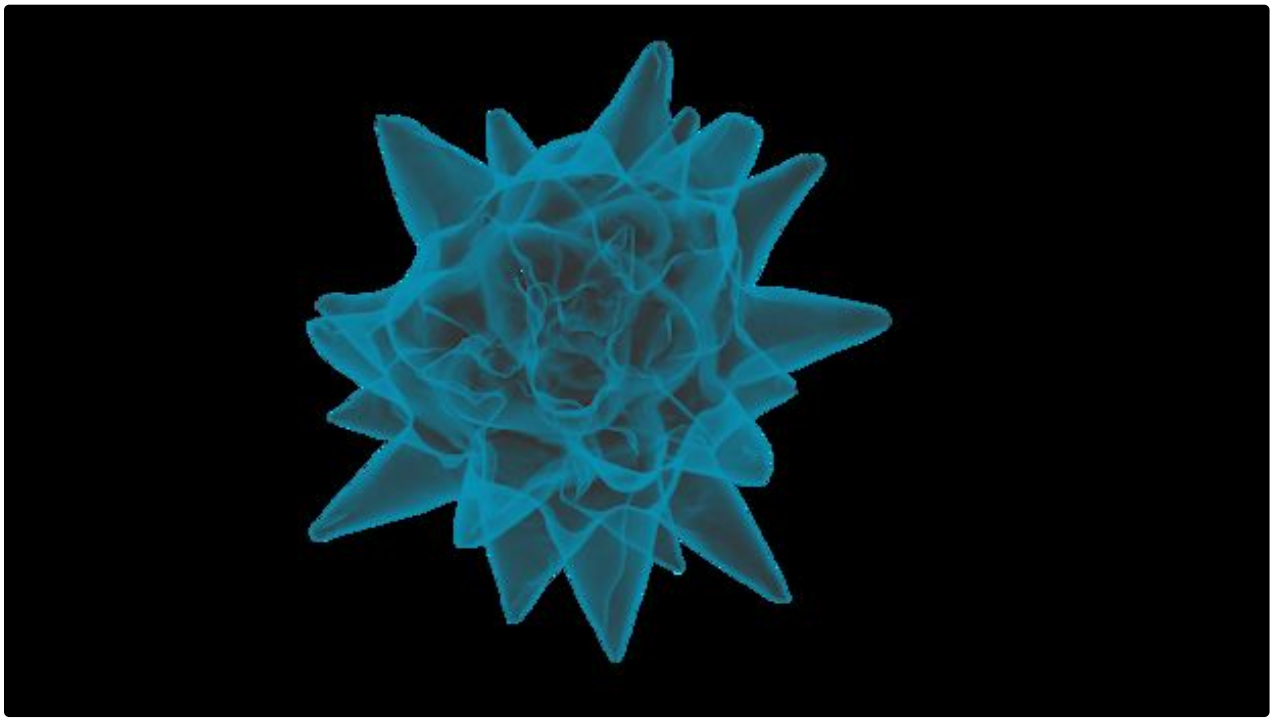
But before we move on, fee free to show us how your 3D model is looking now that you've used some editing tools to clean it up!

LESSON 6: 3D MODELING WORKFLOWS



3D models from 3D scans are amazing, but to some degree they are useless if they just stay inside the program that made them, so what can we do with them? How do we make them useful?

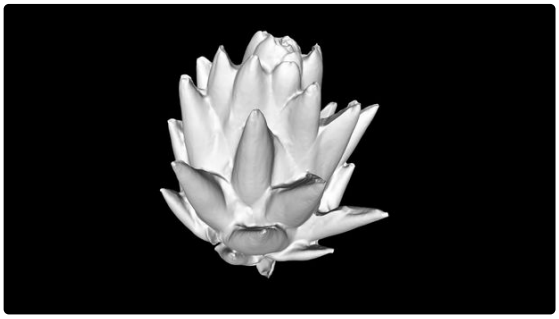
In this lesson I'll show you how to export your 3D models for all kinds of purposes from simple images and videos, to models that can be edited and made into physical objects that are actually functional.



Exporting Your Model As an Image or Video

If you want to show off the scan you've created so you can post it on a website or use it in a portfolio, ReCap Photo has some fun tools for generating nice looking images and videos to display your model.

To export a simple image that will be nicer than a screenshot, position your model how you'd like it to be viewed and click on **export image** under the Export icon. From here you can export a PNG and choose your file size and model display mode.



A static image is fine, but to really show off your model, it's fun to create a video of it in 3 dimensions. To do this, click on the **export video** icon. Here you can create a simple video that shows your model rotating by selecting 'Turntable'.

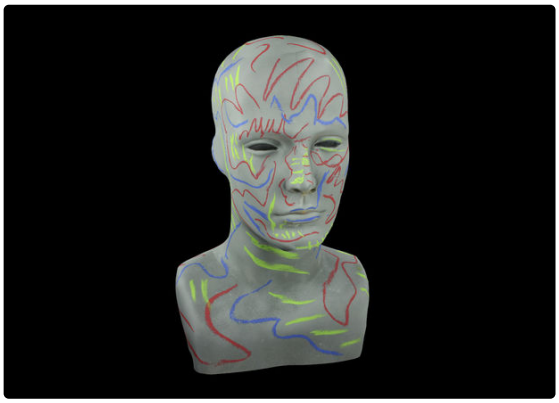
https://player.vimeo.com/video/211578341?title=0&byline=0&portrait=0

Or you can create a more interesting video by clicking on 'Key frames' and then choosing a few model positions you want the video to cycle through. You can even make the model switch between different display modes throughout the video, it's pretty cool :)

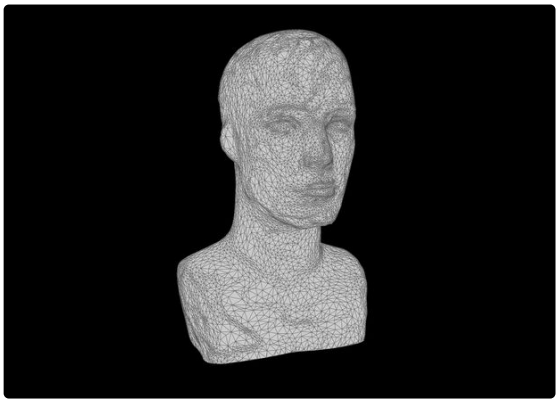
https://player.vimeo.com/video/211576443?title=0&byline=0&portrait=0

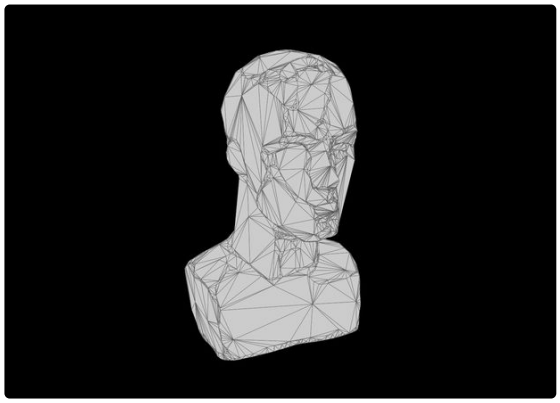
Exporting for Gaming or VR

One common application for scans created with photogrammetry is in the virtual world as assets in virtual reality (VR) or gaming. This is when you are most likely to use the textured, or color mapped, feature of your scans. I think photogrammetry models work especially well for these purposes because the textured layer almost always looks better than the solid geometry of the model itself.

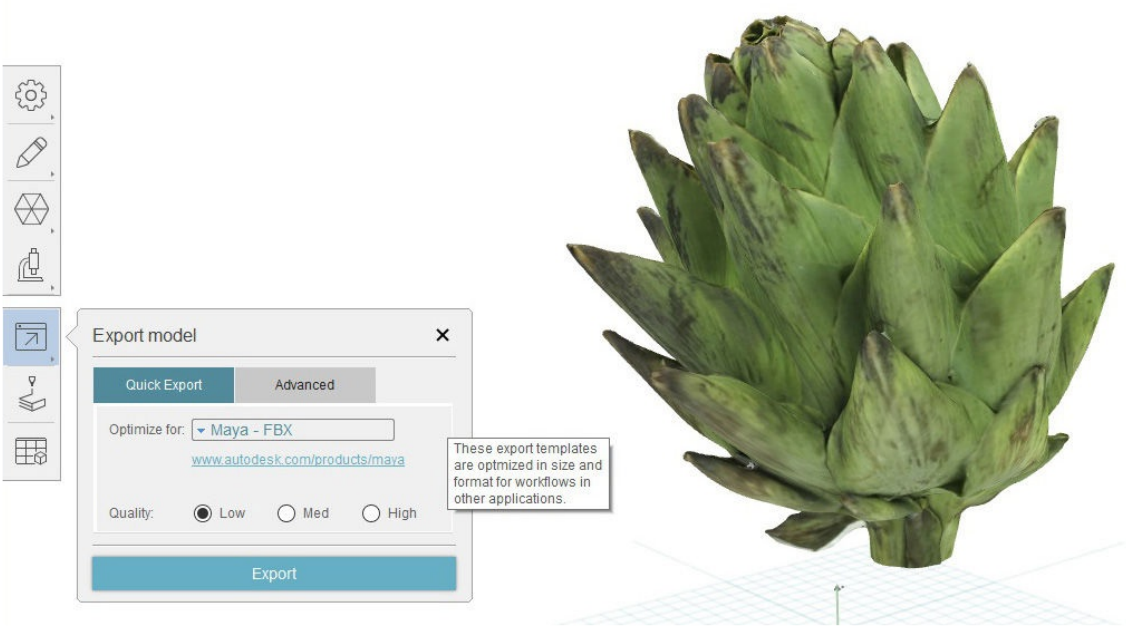


As I mentioned in an earlier video, you can decimate your model to a low polygon count while still maintaining the nice look of the textured layer, which is great for VR and games that need smaller file sizes. To export a model like this, use the **mesh report** function under Analyze to see how dense your mesh is. If it's too dense for your application, you can then decimate it as low as possible without losing its fundamental shape.

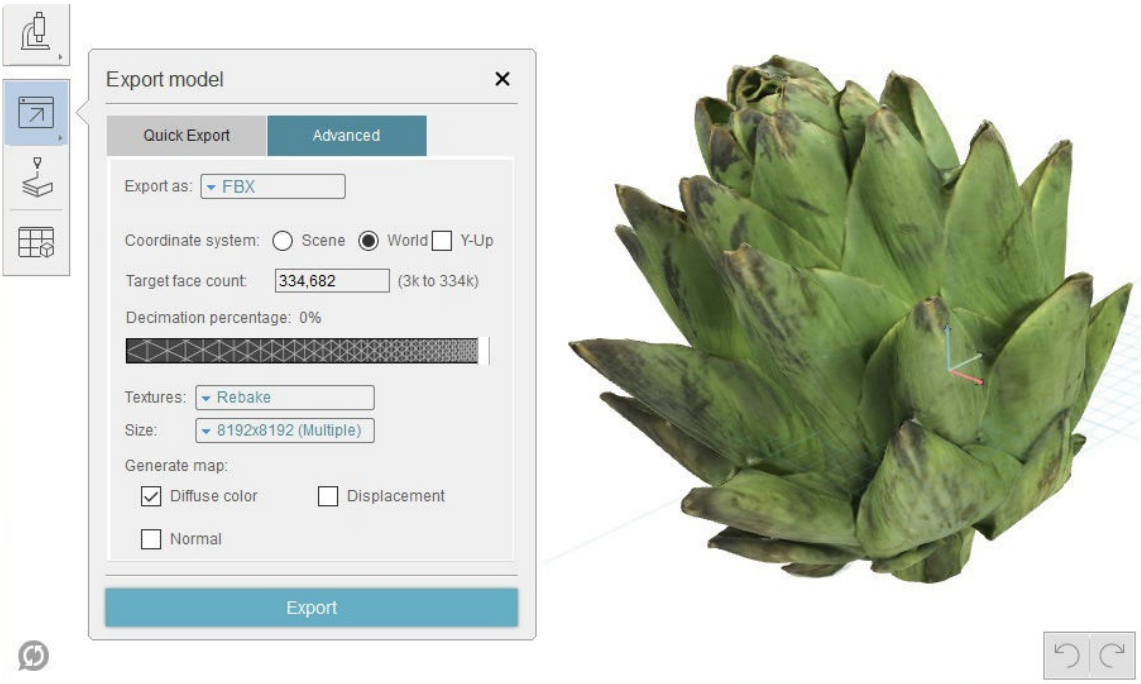




To export your model, click on **export model** under the Export icon. 'Quick export' will let you choose from a set of Autodesk programs to export for and will optimize your model for use in that specific program. To create assets for gaming or VR you might be using a workflow that involved Maya, Meshmixer, Mudbox or Stingray, so you would choose one of those options, and then choose the quality of your model.



If you are planning to use your model in a different program, or just want more control over your export, you can click on 'Advanced' which lets you choose your file type, how much your model is decimated, and options for what kinds of texture maps are created and exported with your model.



Models can be exported to be used as backgrounds and static scenery in games and VR environments, or even transformed so they can be animated to create creatures and characters through applications like Maya.

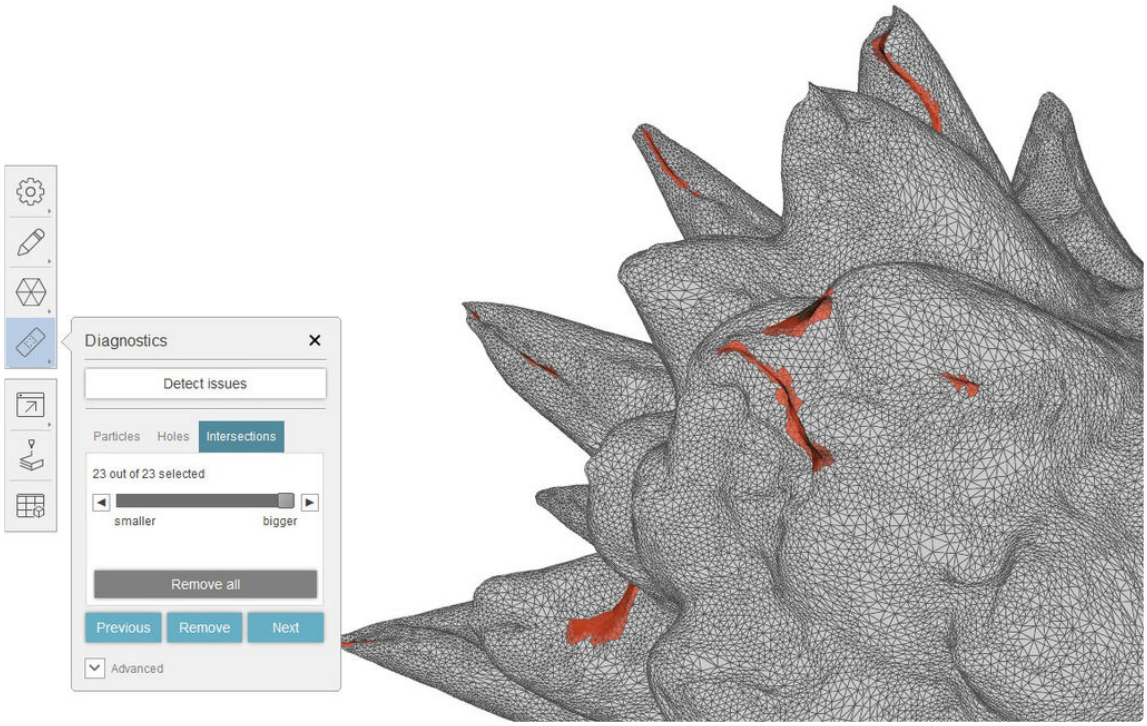
Check out this great Webinar for more info about workflows that can take ReCap scans and turn them into animation assets using Mudbox, Photoshop and Maya. Starting at about minute 41, Craig Barr gives a great demonstration of how it is possible to turn a scan of a human face into an animatable "digital double". Workflows like this take a lot of advanced knowledge, but it's fascinating to see the possibilities!

3D Printing Your Model

If you want to take your model out of the digital world and make it into a physical object, one easy way to do that is with 3D printing. To 3D print your models, you have to first make sure they are solid, with no glitches or holes in the surface.

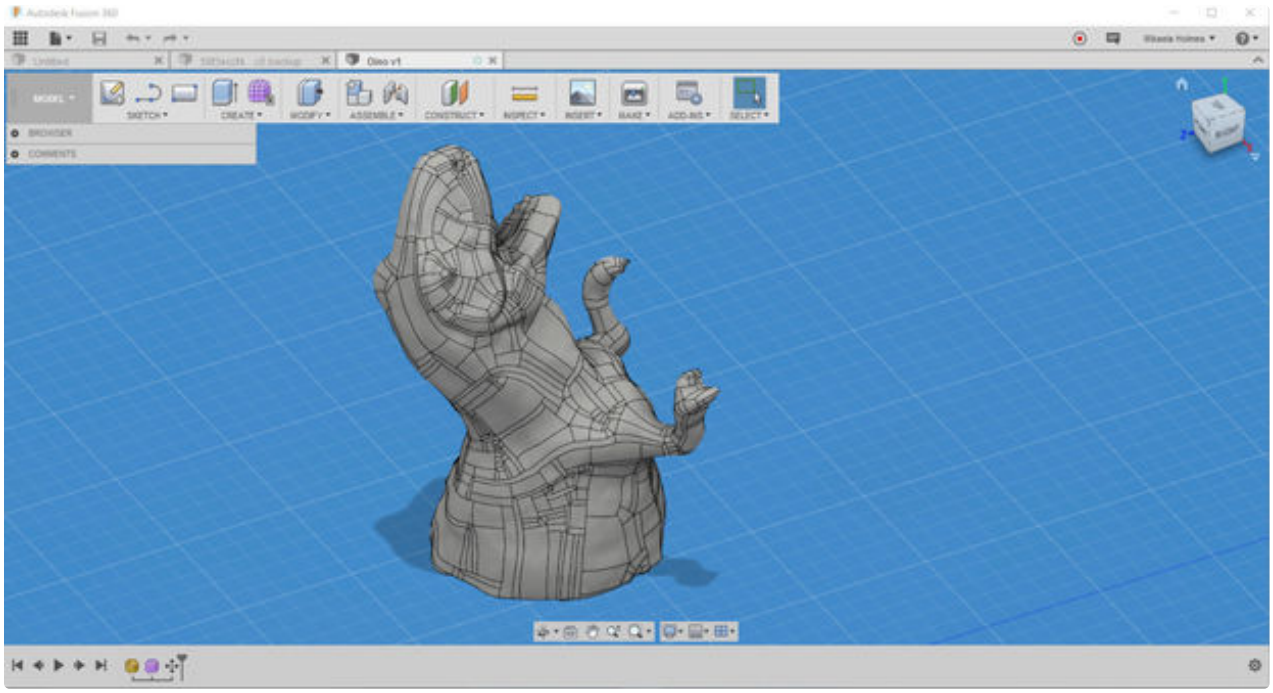
https://player.vimeo.com/video/210668079?title=0&byline=0&portrait=0

To do this, click on Analyze and then the bandaid icon that says **detect and fix model issues**. Hitting 'Diagnostics' will inspect your model to see if there are any **holes**, **particles** (tiny bits of model stranded in mid air), or **self intersections** (places where the surface of the model folds on itself in an odd way). Clicking through the detected problems you will have the option to either let the tool fix them automatically, or fix them manually yourself. if they are complicated, I sometimes like to fix them myself because the automatic fix can create more weird issues.



When you are ready to 3D print, click on the Export tool and save you file as as the file type you need for your specific printer. STLs are a standard file type for most 3D printers, but check with yours or the 3D printing service you want to use. Also, for more tips on 3D printing, check out JON-A-TRON's awesome Beginner 3D Printing Class.

To see an example of a simple project that uses 3D scanning and printing by exporting directly from ReCap, check out my Starfish Earrings Instructable.



Exporting to Other Modeling Programs

ReCap Photo has some great tools for cleaning up your model, but to do some really serious 3D modeling, you will usually need to export your model to another modeling program. As I mentioned before, ReCap Photo has automatic presets for exporting to different Autodesk applications, or if you are more familiar with another modeling program you can just use the advanced export tools to save your model as the file type supported by your program.

Meshmixer is a great program to export to if you want to really be able to edit your mesh, sculpt, fix mesh issues, combine models etc. To export to Meshmixer you will need to save your file as an OBJ which is the file type supported by a lot of mesh editing applications.

If you want to alter your model to make it a more functional object, give it points of attachment, combine it with other models you've created etc., a great program to export it to is Fusion 360. Fusion is another Autodesk program that gives you the ability to create all kinds of 3D designs from simple to complex, organic to mechanical in a user friendly interface. And one of the best parts about it is that it's free! If you are a student, educator, startup or hobbyist, you can download Fusion totally free with all its normal functionality. I'll be talking a little bit about how to use a mesh in Fusion in the next section, but if you want a more in-depth intro to Fusion, check out JON-A-TRON's most excellent 3D Printing Class.

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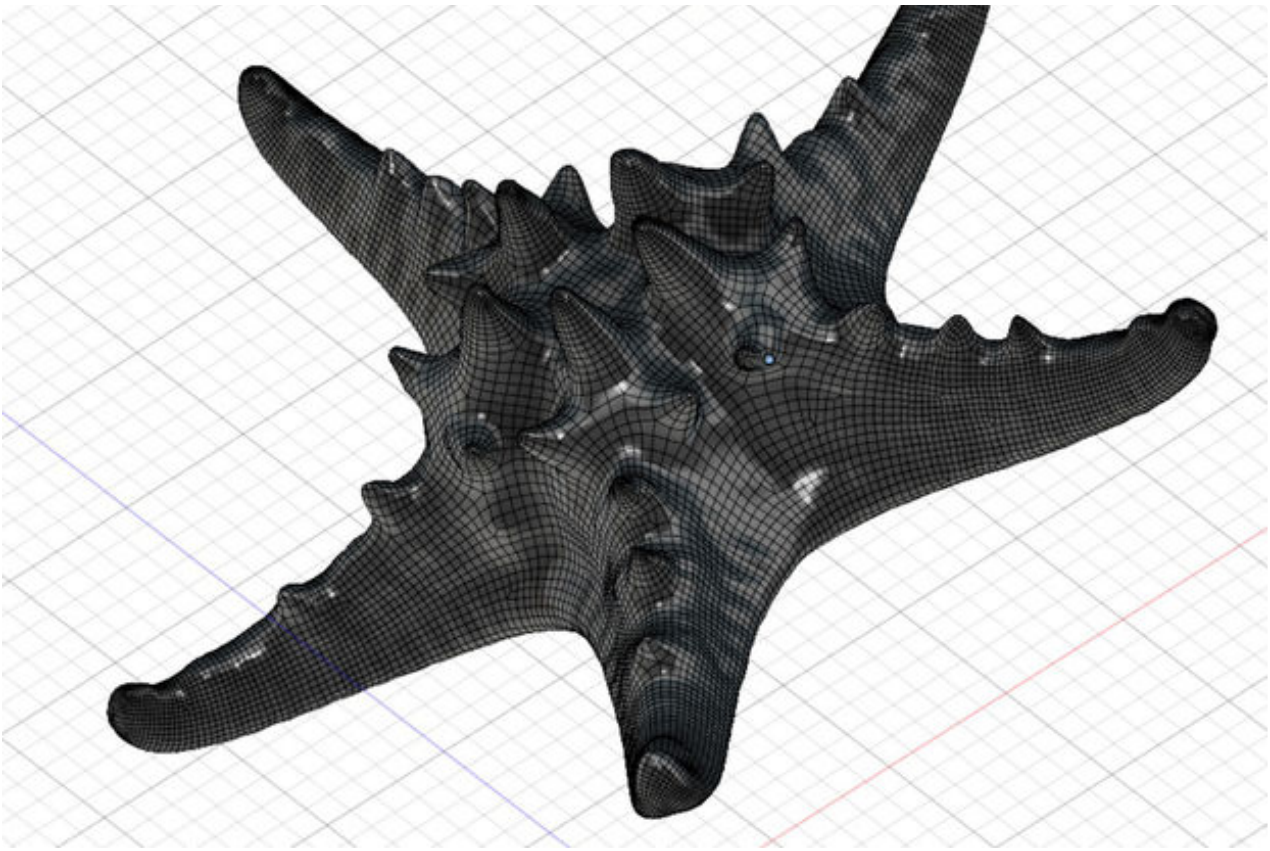
To use your mesh model in Fusion, you need to export it as an 'OBJ with quads'. To do this, choose Fusion 360 in **quick export**, or OBJ (quads) in **advanced export**. Meshes can have different structures, the meshes of regular OBJs are made up of triangles, but the these special quad OBJs are made up of quadrilaterals. The geometry of these meshes is better for certain kinds of modeling and is the only way to make meshes editable in Fusion. For a longer discussion about the difference between modeling with quads and triangles, see this great Instructable by Amy Karl.



Working With Meshes in Fusion

Bringing scanned models into Fusion is a workflow that opens up a lot of possibilities for creative uses of 3D scanning. When you can manipulate your models in precise ways, you can integrate them into functional objects, or use them as templates to create designs with similar shapes, or components that will interact with them.

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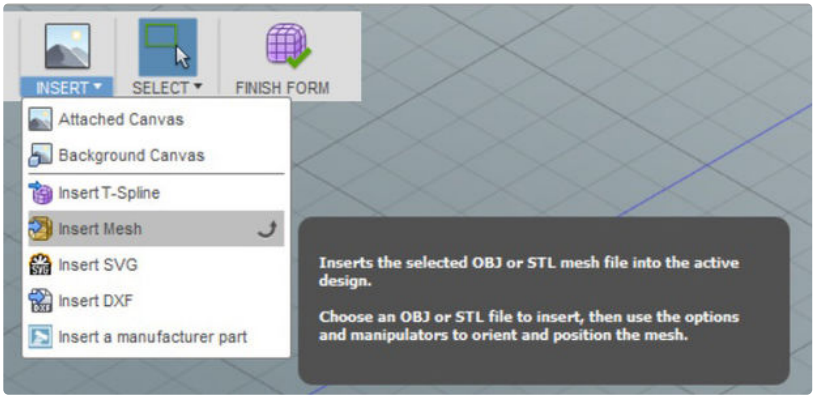
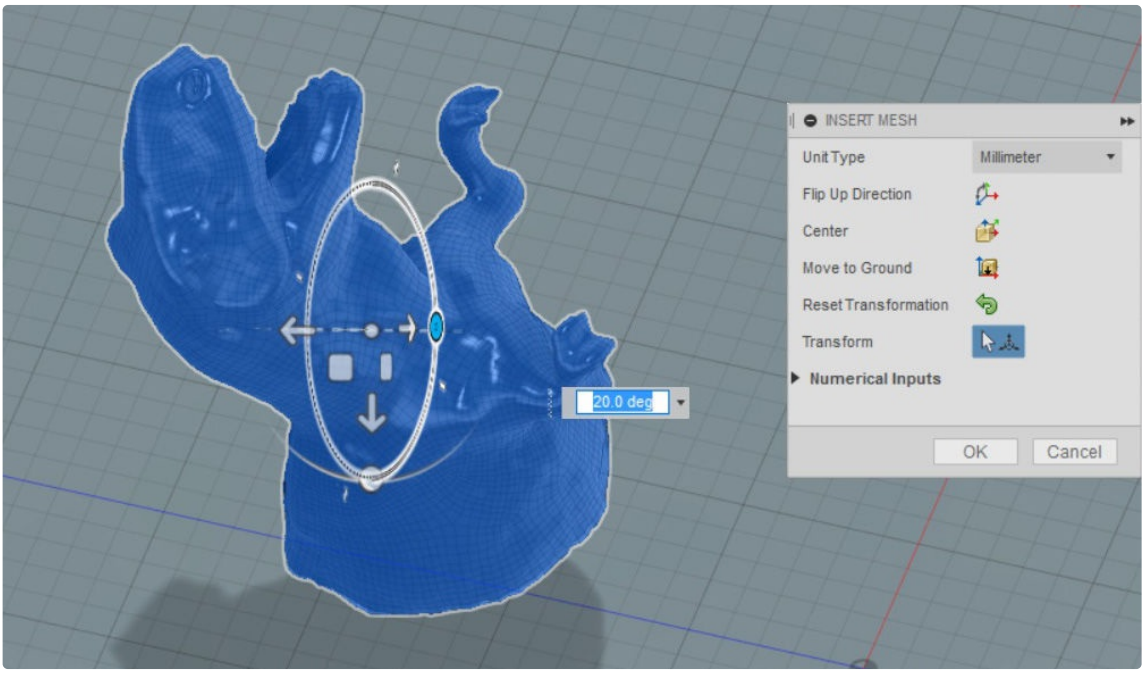
To bring your quad Mesh into Fusion, open Fusion and click on Create Form in the top toolbar. This will bring you into the **sculpt** workspace in Fusion. Fusion has several modeling environments that allow you to create different types of 3D forms using different modeling strategies. The sculpt environment is where you can create and modify forms that are built on T-splines, a type of 3D model surface that allows shapes to be more curved and organically editable.

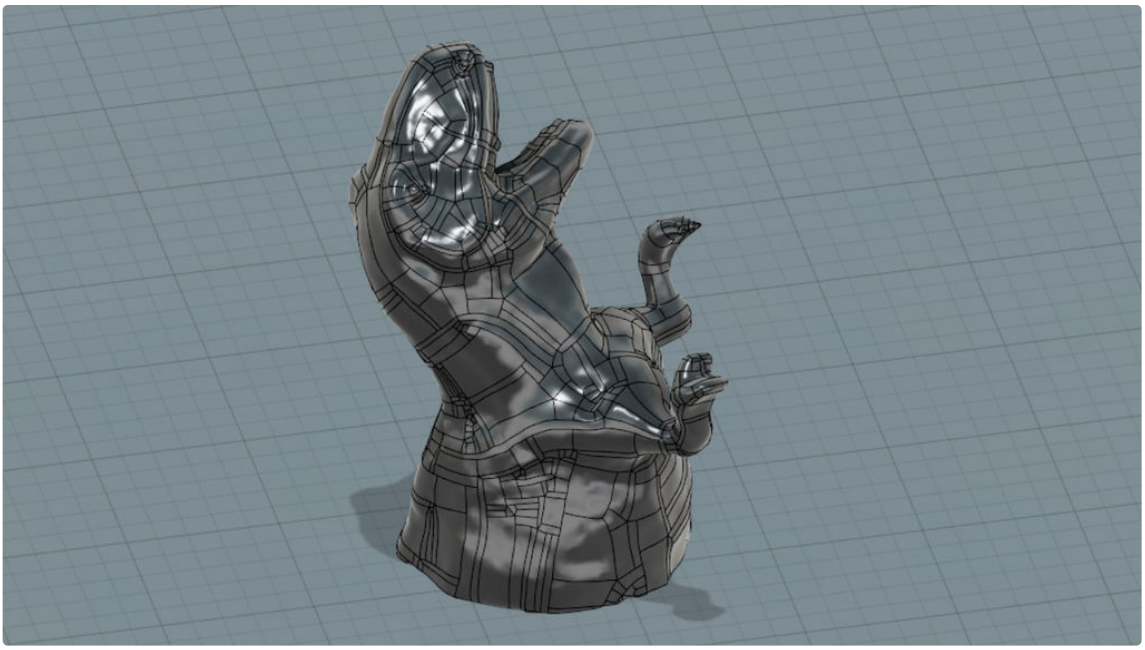


In the sculpt environment click on Insert in the top toolbar, then select **insert mesh**. Browse to the quad file you exported from Remake and open it. In the dialog box you can set your units of measurement and you can use the blue arrows and gizmo wheels to adjust the position of the model. If your model had a lot of complex detail, you will see that converting it into quads eliminates a lot of this detail and makes the surface much smoother. Sometimes this will work for a design and sometimes it won't, but if you want your mesh to be editable in Fusion, unfortunately you have to accept this loss of detail.



Once your model is imported as a mesh, you will be able to see it, but you won't be able to edit it. To convert your quad mesh to a **T-spline body** that can be edited, right click on it and choose **convert**, then click ok in the dialog box. Now you can edit your model using the tools in the Fusion sculpt environment. This means that each face, edge, or vertex of the mesh can be selected and moved around to change the shape of the model. Do this by selecting **edit form** under Modify, then selecting the elements you want to edit.

You can do any organic, shape related modeling in the sculpt environment, and then click on Finish Form in the top toolbar to bring your model into the Modeling environment. If Fusion detects any flaws in your model as it is trying to convert it from a T-spline to a **solid body**, it won't be able to make the conversion and an error message will pop up. The flaws in your model will be highlighted and sometimes you will have to patch holes or cut away and re-attach sections of your model to fix it.



When your model does successfully convert to a solid body in in the modeling environment you will be able to edit it using solid modeling tools like sketch, extrude, split, combine and chamfer. You can use these tools to make holes in your model, cut it apart, add more precisely modeled elements, combine your model with other models and much much more. The ability to manipulate your model in these ways can transform it from a knick knack, into something that combines functionality and design.

And Now...

Make something awesome with 3D scanning!

Now that you've learned the basics of capturing reality with 3D scanning, try using the techniques I've covered in this class to make something unique. Workflows like the one I just described with Fusion 360 will open up a lot of design possibilities for your 3D scanned objects. Once again, check out JON-A-TRON's 3D Printing Class for some great Fusion tutorials.

There are an endless number of interesting and useful things you can create when you combine 3D scanning and 3D modeling. I've seen people scan broken objects in order to create new versions, sculpt prototypes for products out of clay and then scan them, use scanned objects as references to model around, and hundreds of other unique workflows. To see some examples of what you can create by combining scanned meshes with solid modeling, look in some of the projects in the "What's Next?" section at the bottom of the Class page. Also check out some of the great videos on the ReCap Photo website, like this one about designing custom wine glasses.

If you do create your own project with the skills you've learned, be sure to share some photos of it below and please publish an Instructable about it or enter it in one of our awesome contests!