

# GETTING STARTED



A GUIDE TO  
**PHOTOGRAMMETRY**

# Table of Contents

<b>What is Photogrammetry</b>	<b>3</b>
<b>Getting Started</b>	<b>4</b>
<b>Camera Setup</b>	<b>5</b>
<b>Scene Setup</b>	<b>7</b>
<b>Capturing</b>	<b>8</b>
<b>Materials</b>	<b>10</b>
<b>Improving Your Results</b>	<b>11</b>
<b>Single Acquisition</b>	<b>13</b>
<b>Multiple Acquisitions</b>	<b>14</b>
<b>Creating a New Capture</b>	<b>15</b>

# What is Photogrammetry?

Photogrammetry is the practice of determining the geometric properties of objects from photographic images. This is done by comparing and matching pixels or reference points across a series of photos. A photogrammetry software (such as Agisoft Photoscan or Autodesk Remake) is then able to process these photos, and by matching and triangulating on visual features, they construct a 3D mesh.

Through trial and error, the UM3D Lab has compiled a collection of methods that were helpful in creating quality models. If you are interested in learning more about photogrammetry or have any questions about the methods presented in this guide, please feel free to contact us.

## Visit our website

[um3d.dc.umich.edu](http://um3d.dc.umich.edu)

## Swing by the UM3D Lab

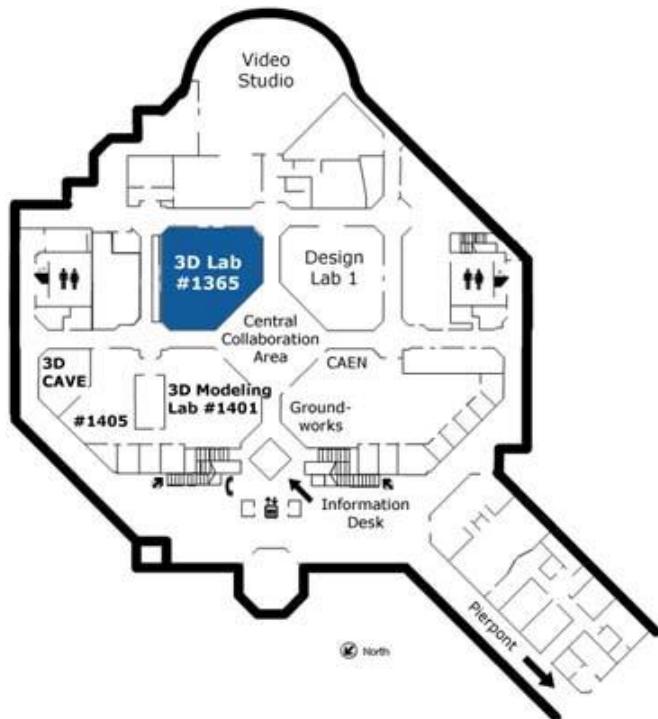
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# Getting Started

To begin capturing subjects with 123D Catch, we recommend using the following:

- ***Camera:***

The quality of your reconstruction depends on the quality of your camera. We recommend a high resolution DSLR with good color depth. Having a fixed lens is best for photogrammetry, as these have fixed zoom and therefore no change in focal length. While this is ideal, 123D Catch is not restricted to expensive cameras. A standard point and shoot camera will yield a 3D model as well, however, the detail, accuracy and distortion will be different.



- ***Tripod:***

Although not required, a tripod can be useful to avoid blurriness and to keep photos consistent.

- ***Monopod:***

A monopod may also be of use if capturing tall buildings or objects.

- ***Self-Timer or Remote Clicker:***

Photos need to be entirely in focus, and often good lighting is not enough. The shutter speed must be long, making it difficult to obtain sharp images without a clicker or timer.

- ***2x Batteries and Charger:***

Capturing high definition images drains battery power fast, and coming back to a site at a later time is not an option, as lighting and environmental factors may change in that time. Having enough battery power on hand is crucial.

# Camera Setup

Proper configuration of your camera is crucial to your success with 123D Catch. For optimal results, you should try to adhere to the camera configuration described below.

## Avoid Using Automatic Mode

Photos should be captured with the Manual setting on your camera. Automatic mode forces the camera to adjust to every new angle, resulting in different lighting or focus for each shot.

## Keep Zooming Fixed

Zooming should be constant throughout the capturing process. Zooming in and out brings uncertainty to the calculation used to process your images due to changes in the lens distortion. Because of this, it is best to make use of a fixed lens.

## Keep Photos Sharp and in Focus

Blurriness makes it difficult for the system to process details in a photograph, and one blurry photo can affect the entire reconstruction.

## Deep Depth of Field

Depth of field must be as deep as possible (F.8 or greater) so more objects are in focus. This provides the software with more reference points. Set your F-Stop as low as possible (F11 or below) and use a small fixed aperture for crisp results.

## Lower ISO

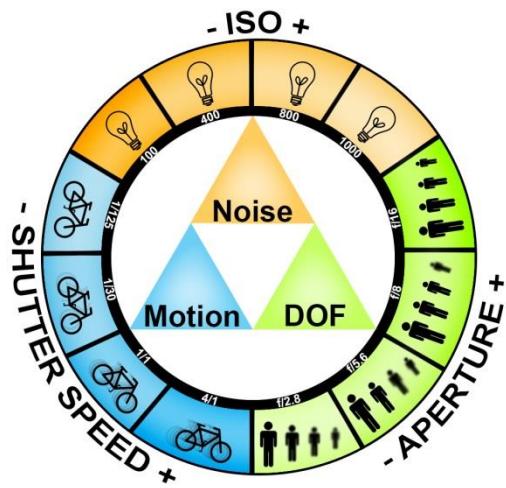
Your ISO determines how sensitive your camera is to incoming light. Lower ISO is always preferred, as high ISO results in a lot of noise. You should only raise ISO when you can't obtain the desired shutter speed and aperture.

## Shutter Speed

Your shutter speed defines how long light is allowed to enter the camera. Faster shutter equates to shorter exposure. Depending on the subject you are capturing and its surrounding environment, you should set your shutter speed accordingly.

## Avoid Under or Over Exposure

Try not to over or under expose your photos, as dark shadows and washed out lighting can mask important details when processed.



## No Flash!

Never use a flash. A flash illuminates the foreground, thereby changing the lighting and precieved positioning of each shot. Accurate lighting is key to translating your subject's position in space.

## RAW Format

Always use RAW format if your camera supports it. RAW is an un-processed format (12,14, 16 bit depth) that supports up to 28 million colors, as opposed to JPG (8 bit depth) which only supports 16 million colors. Capturing your subject in RAW allows for more precise editing should you need to alter your photographs prior to submitting them to 123D Catch.

# Scene Setup

## Lighting

When lighting your subject it is important to keep your scene consistent. For best results, use diffused light to avoid over exposure and try to eliminate any harsh shadows that may conceal details of your subject. Shadows on an object may be mistaken by the software to be holes in the object you are capturing, and consequently will be reflected in the resulting reconstruction. For interior shots, you should avoid the use of spot lights and your camera's flash, and also be aware of any flickering or occluded lights throughout the capturing process. For exterior shots, it is best to capture scenes during the early morning or later in the afternoon, when sunlight is not so bright. Remember to adjust the aperture and shutter speed of your camera according to the lighting. If your photos are too light or too dark, the software will have more trouble locating points of reference.

## Importance of Backgrounds

Your background plays a key role in the quality of your model. With the incorrect background, your reconstruction may appear warped. Ideally, you will want to select your background to work in conjunction with the properties of the subject you are trying to capture.

When capturing monochromatic objects, it helps to feature a rich background that is high in detail, color or patterns. In turn, when capturing a rich object, a monochromatic background works well. This is intended to separate your object from its environment, so you will want to avoid backgrounds that blend in with the object you are capturing. In instances where the background and the object are too similar, the software may have trouble telling where your object ends and the background starts. Additionally, try not to disturb objects in the surrounding space-these are important for tracking your relative position to the object, and moving these between shots confuses the software when attempting to match reference points. You should always make sure you have adequate room to navigate around your subject before you begin the capture process.

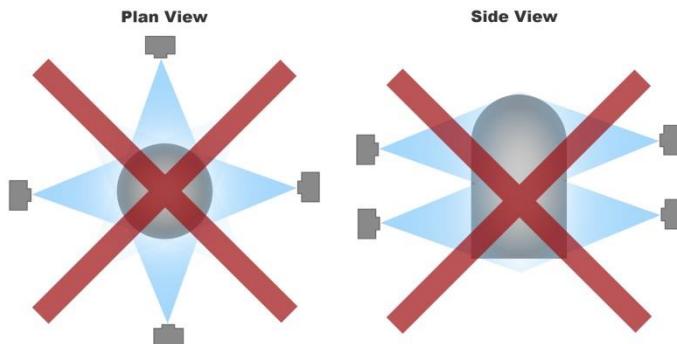
# Capturing

## Fill the Frame

The object of interest should take up 70% of the frame or more. For most standard sized objects, having at least three feet between you and the object is adequate for capturing. For large structures, like buildings, you will need to position yourself much further.

## Overlap Photos

Photographs should overlap every 5-10 degrees as you capture an object. You want at least 50% of a photo to overlap with another-the more your photos overlap, the better your reconstruction. Additionally, these photos should be taken at, at least two different heights. When capturing, try to circle your object instead of focusing on the front, back, left and right.



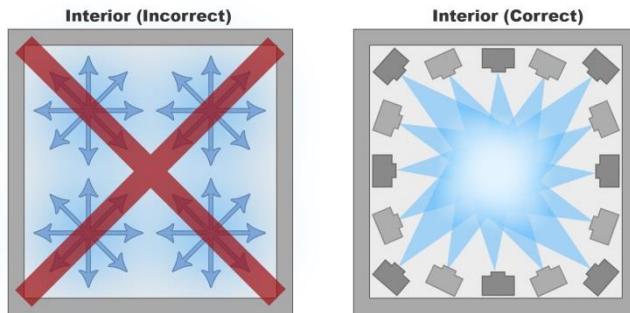
## Take Several Photos

The more photos you capture, the greater chance you will end up with an accurate model. For most objects, the software requires at least 25-60 photos to produce a model, however, if the object you are trying to capture is particularly intricate, a maximum of 200 photos may be required. It is also important that your photos are not blurry. One blurry photo can alter the entire reconstruction.

## Positioning

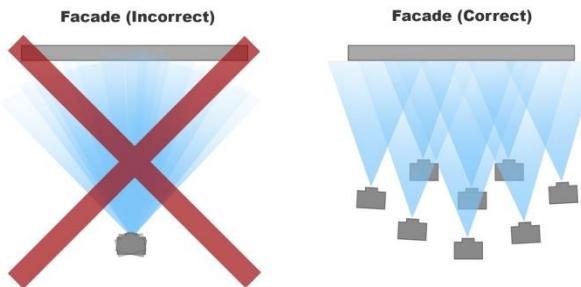
### *Interiors:*

Photos should be taken with your back against the wall, along the perimeter of the room facing toward the center.



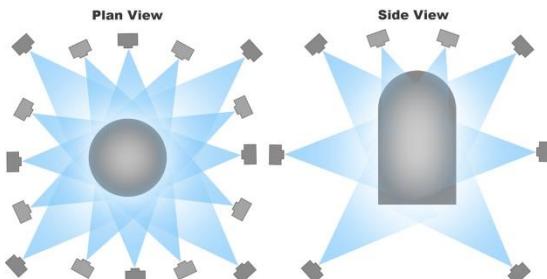
### *Facades:*

Photos should be taken moving horizontally and vertically. Do not stay in one place and rotate to capture images, as this captures from a single focal point.



### *Objects:*

Photos should be taken rotating around the object.



# Materials

Objects that do not have the proper material will not yield a quality reconstruction. These kinds of objects generally produce holes in the resulting meshes, or extensive warping. However, there are some existing techniques that may improve your results when attempting to capture materials such as these. Photogrammetry has difficulty capturing the following types of materials:

## Clear Objects

The trouble with clear objects stems from the fact that the software uses reference points to create a digital model. When an object is translucent, the software cannot track the movement of the object. In objects that are partially clear, the translucent area is often mistaken for a hole in the object. If the translucent area is also reflective, such as glass, the reflection may be mistaken by the software as a reference point that travels across the surface, warping the resulting reconstruction.

## Shiny Objects

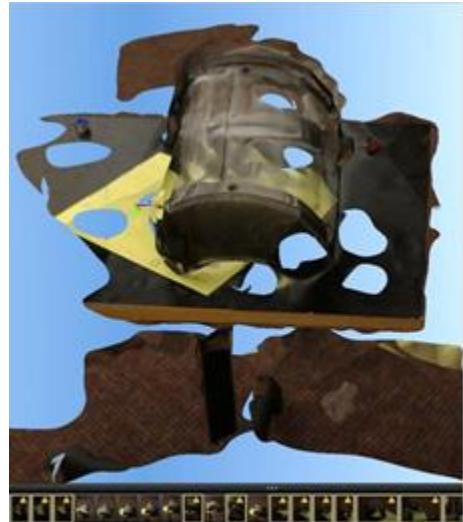
If shine is visible on an object it will be problematic to capture. With shiny objects, the part that is reflecting light changes as you move about the object. The software then misinterprets the patch of light as a constant reference point and warps the reconstruction. If you are trying to capture an object that is shiny, it is advised to first dust the object with talcum powder to lessen the amount of shine.

## Black or White Objects (Uniform Color)

Objects with a light or dark uniform color can cause problems with 123D Catch because of a lack of reference points on the object. Thus is mostly due to the quality of the camera, as most cameras cannot pick up enough detail in these types of objects to produce an ideal amount of reference points.

## Flat or Geometric Shapes

Geometric shapes such as cubes or rectangles can cause problems as well. While it will not prohibit the object from being captured, it may produce a model with bumpy sides instead of the desired smooth sides to geometric objects, or confuse the angle of corners.



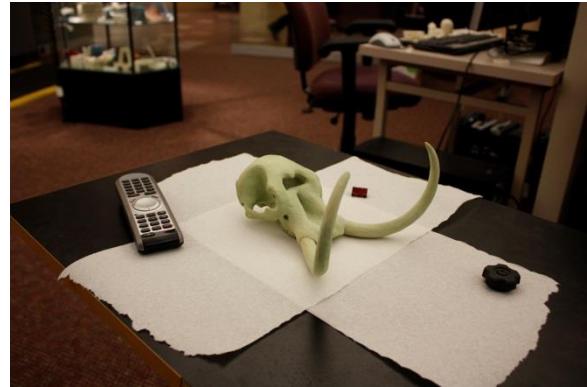
123D Catch had trouble with this clear, shiny, and uniformly colored object.

# Improving Your Results

If you are not satisfied with your reconstructed model, there are some things that you can try to improve the result on your next attempt.

## Symmetrical Objects

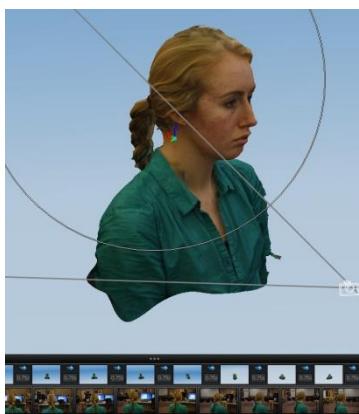
Symmetrical objects can often be difficult for the program to track. If your object is symmetrical, you can try placing small satellite objects around the subject so that the program can tell the symmetrical sides of your subject apart. Placing these small objects 3-6 inches away from the subject tends to yield a good result. Make sure your satellite objects vary in size, shape and color and are not larger than the object you are capturing.



Our satellite objects varied in size, color and shape.

## People

People are actually one of the easiest subjects to capture using 123D Catch; however there are still some difficulties that must be addressed. Capturing



Braided hair helps 123D Catch model hair

people works best when the backgrounds, as well as the subjects themselves, have many distinguishable features. Dark skin and loose, dark hair, is especially difficult for the software to process due to the uniform shape and color. In addition to the lack of reference points in hair in general, dark hair or skin is often mistaken to be shadows. Having your subject place their hair in a ponytail or French braid helps resolve these issues by exposing more of the face, and thus more features that can be tracked. Braided hairstyles also contain patterns that act as reference points, allowing the features of the hair to be tracked. When capturing people it is best to use good lighting, a high resolution camera, and possibly markers for the face and hair. For some extreme cases, photos may need to be lightened in Photoshop prior to being processed by 123D Catch.

## Buildings

When reconstructing buildings, there are many aspects that must be considered. Reflections from glass windows can warp the resulting model. It is best to capture buildings with several windows

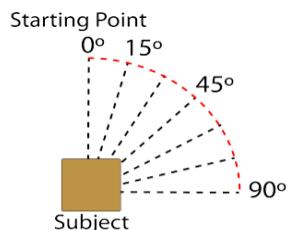
on cloudy days where there is less shine and reflection present in the glass. Alternatively, a polarizer may help to remove some of the reflection.

Objects in front of a building may also present problems. Trees and telephone poles are common obstacles. It is best to rotate around a building to capture the area between these objects and the subject, so the software does not interpret these obstacles as being attached to the surface of the building. Movement is also a big issue. You do not want many people or moving cars around when taking your pictures. Although this can be difficult when your building is in a busy area, you can try to photograph your building when people will not be around, such as a weekend or early in the morning. Size and geometric shape may also cause problems. If the building is extremely large, the number of photos necessary for capturing the model may be too large for the software to handle. You may have to delete non-essential photographs and settle for a less precise reconstruction, or capture the building in sections.



Capture buildings on a cloudy day to avoid harsh window reflections that may distort your model.

When capturing the corners of buildings, it is important to move around the corner at 15 degree intervals until you are once again parallel to a flat surface:



## Small Objects

Object size is another important factor in the production of a model, especially if an object is smaller than 2"x3"x2". This is due to camera focus. A small object may become blurred, resulting in less tracking points. A possible solution is to use a macro lens for your camera.



Small objects have a tendency to go out of focus.

## Undersides of Objects

Capturing the underside of an object that is resting on a surface will require multiple acquisitions. These reconstructions are then combined in 3D software such as 3D Studio Max or Maya to form a complete model.

## Accuracy

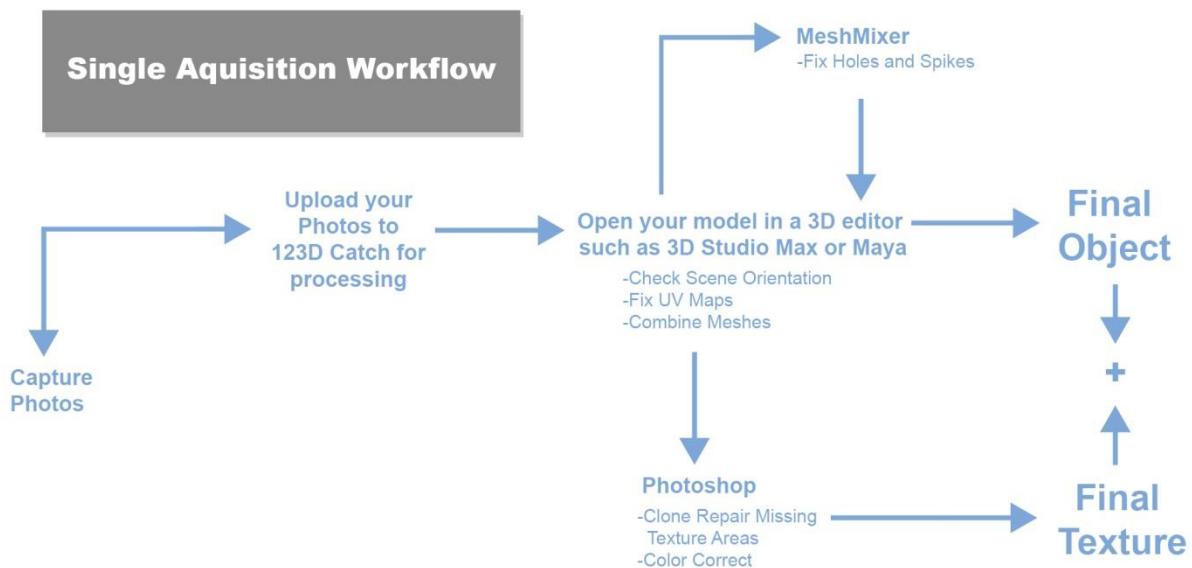
If accurate measurements are important, you may wish to place markers on your subject. Dennison dots can be placed on an object at level, measured intervals. When viewed within the resulting mesh, the placed dots help to know the exact scale of the object. It may also help to include in your scene, a reference for measurement, such as a ruler or coins.



Dennison Dots can aid in producing accurate measurements.

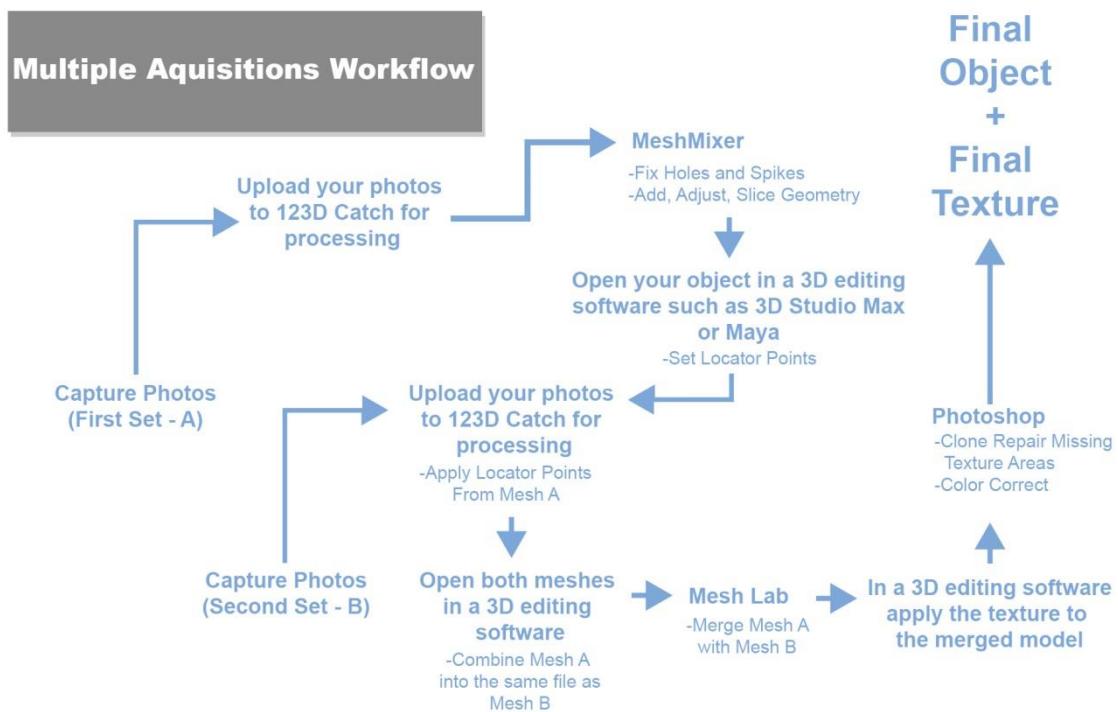
# Single Acquisition

Single acquisition refers to objects that have no underside and can be captured in a single session. These include things like statues, buildings and people. In a single acquisition workflow, photos are taken on site, and then converted into a 3D reconstruction in 123D Catch. The resulting model can then be manipulated in other 3D software such as Meshmixer, to be water tight (for 3D printing), or brought into 3D Studio Max or Maya to be rendered as a turntable.



# Multiple Acquisitions

Multiple acquisitions involve taking two sets of photos from different positions of the object. These two photo sets are then processed independently in 123D Catch to create two separate reconstructions. The resulting models must then be brought into a 3D software to be combined. This involves placing locator points atop one of the models within 123D Catch prior to export, and aligning those points to additional points placed on your other model within your 3D software. These locator points should use the same reference points to ensure the two halves align correctly. Overlapping parts of the combined mesh will then have to be removed, and the two halves will need to be exported as a single file before they can be merged in a program like Mesh Lab. Color information can be preserved in this process; however it may require additional cleanup in Photoshop to ensure proper alignment of features.



# Creating a New Capture

To turn your captured photographs into a 3D reconstruction, the 3D lab offers software to process your photos:

- **Agisoft Photoscan**
- **Autodesk Remake**  
(formerly known as 123D Catch)
- **Autodesk Recap 360**

In most cases these softwares offer unrestricted 30 day trials or educational licenses for students. The above mentioned Autodesk softwares are available in Vislab 1 (Room #1401, ground floor of the Duderstadt Center) with Agisoft Photoscan Pro available within the 3D Lab on a dedicated Photogrammetry workstation.