

3D Scanning

Photogrammetry





a person doing some measuring with images made from light

Etymology:

(Greek)

photo- > phôs = light

-gram > -gramma = something written / drawing

-metry > -metria = process of measuring

Measuring images made from light.

The technique is over 100 years old, initially used in aerial reconnaissance and map-making.

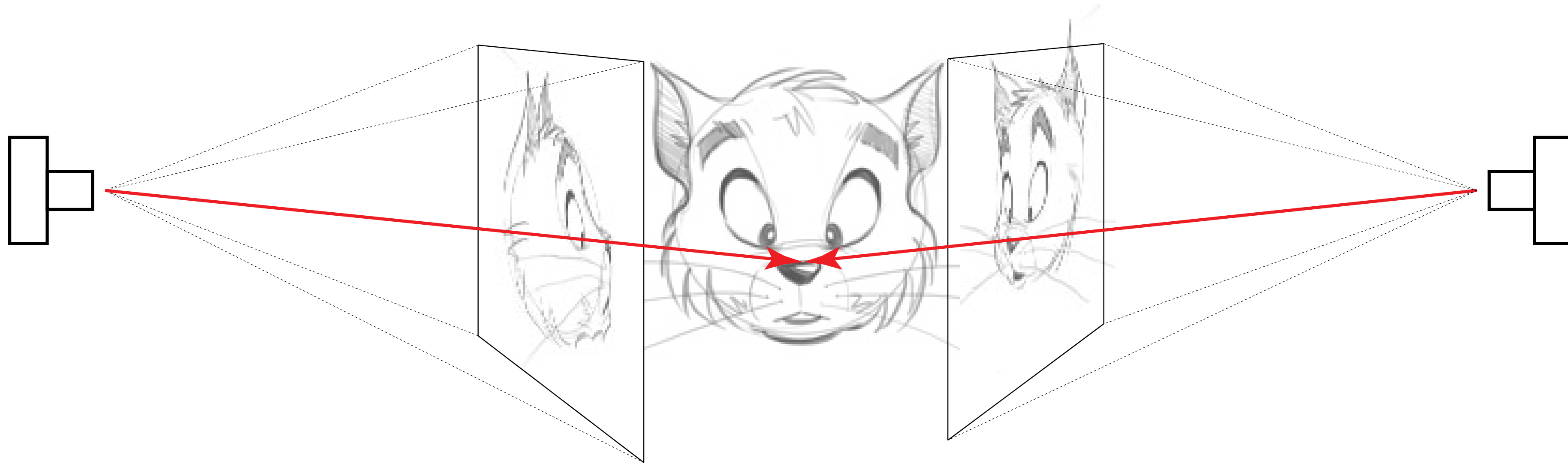
Measuring images

In the simplest case, for one image, the distance between two points on a photograph can be measured directly from the image if the scale of the image is known.

One way to know the scale is to have something of known length in the image, in this case a ruler. Here, whatever X (1" on the ruler) turns out to be when measured directly on the image can be used to estimate the height Y of the cat (the scale of this image will be $X/1'' = X''$. So dividing Y by X gives the height of the real cat in inches).



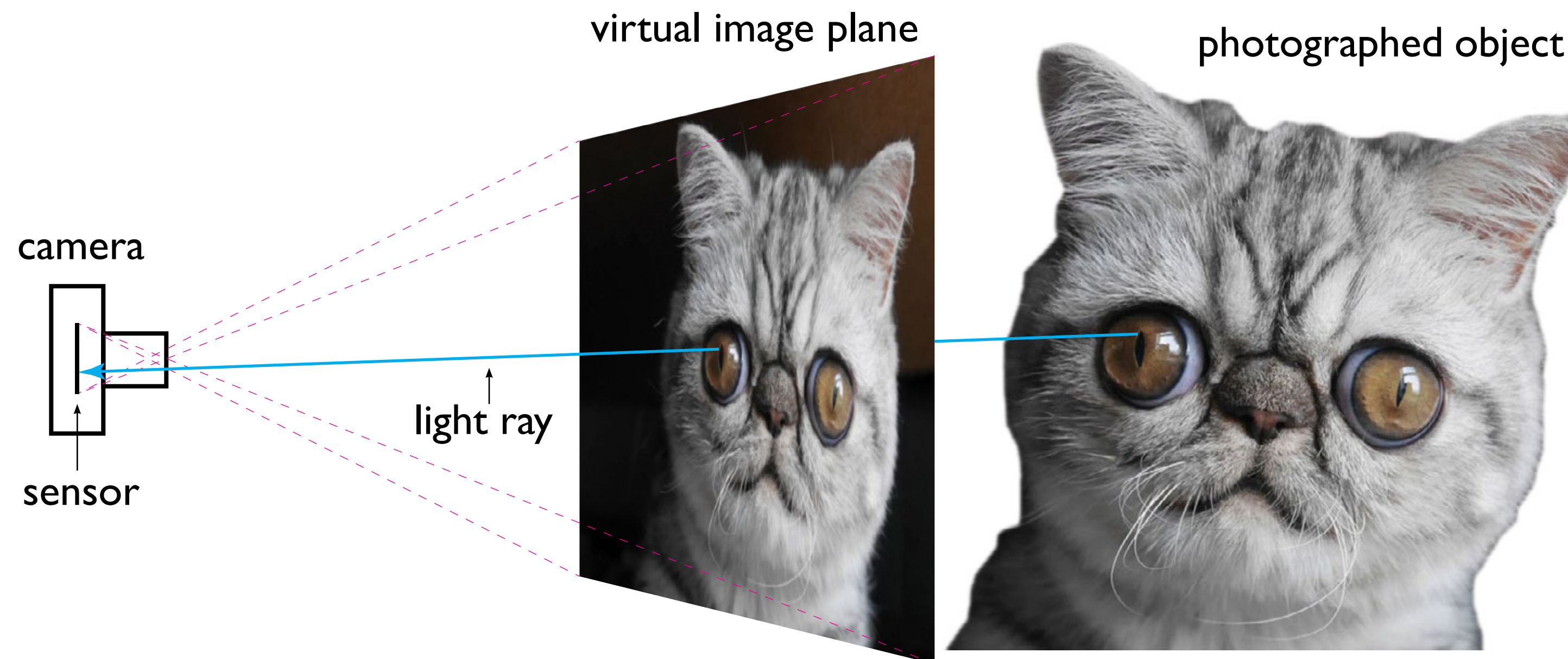
Measuring common points between images



For two images, if we can identify a point on each which is the same, and if we know the position of the cameras that took them, we can draw lines from the camera through the points on the virtual image plane: where they intersect is an estimate of the point's real location in 3d space, in this case the tip of the cat's nose.

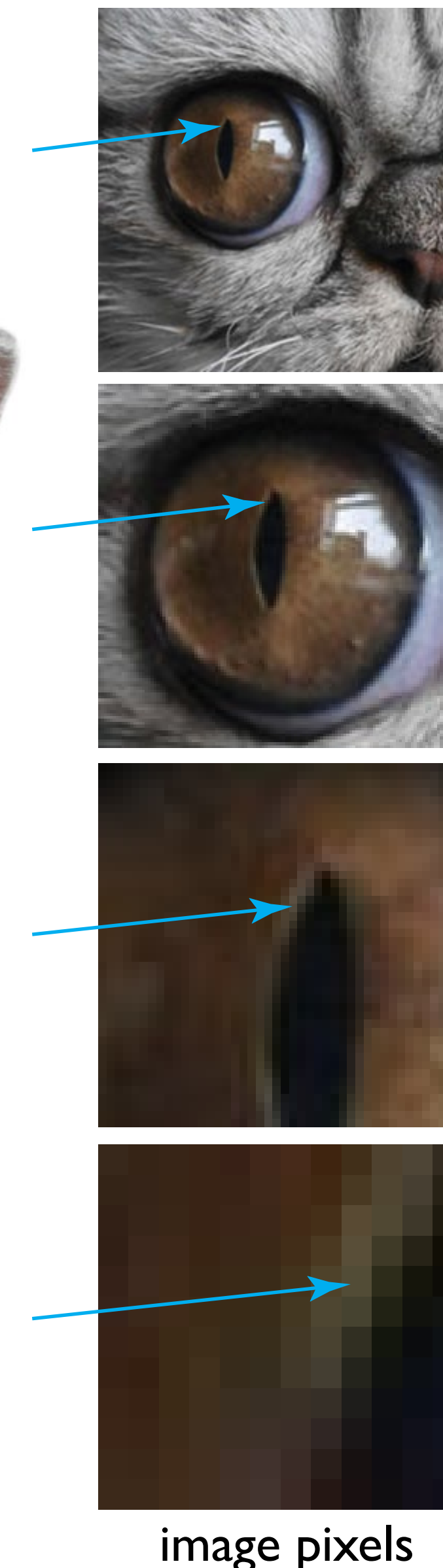
In general, with multiple images, pairs of images within the set can be triangulated to build up a set of points. If enough images taken around the subject are successfully paired, detailed 3D geometry can be obtained.

Light, pixels, and accuracy



A pixel's RGB value can be thought of as the direct(ish) endpoint of a ray of light emanating from an object onto a camera's sensor.

If it can be found that two pixels represent the same point in different images (of the same object, taken at slightly different angles) by analysing their values and local patterns, then they can be thought of as having emanated from the same location in the real world in a straight line to that pixel. The points can then be triangulated between images to build an estimation of the object's 3D geometry.



So, the success of photogrammetric methods relies largely on the quality and consistency of photos you take. If the pixels change value between images as a result of photographic or environmental inconsistencies, then it becomes more difficult to find matching points with confidence.

Part of the accuracy inherent in photography will be down to equipment quality and choice. But whatever is used, there are many aspects to photography which can be controlled advantageously.

In general, accurate photos and consistent shot methodology results in accurate models.

Considerations for taking pictures that make accurate scans.

Light > Object > Lens > Aperture > Shutter > Sensor > Digitisation > Processing > Shot Methodology

Object

Is it reflective? Is it transparent?

- Reflective objects look different depending on viewing angle
- The colours and shapes seen through a transparent object will change with viewing angle
- Use a covering or paint the surface of transparent or reflective objects if you only want to model their geometry

Are there large featureless areas?

- It will be difficult to tell which points are the same between photos
- Add tape, markings or other objects to make the area more detailed, then remove these later

How large or small is it, can you get around it with a camera?

Are there aspects of it which the camera will not be able to see in to?

Is the background consistent, non-reflective, non-transparent?

Light

Will the lighting conditions change with viewing angle?

- Strong, diffuse and even lighting is best
- The aim is to control the conditions so changes of angle do not result in radical changes of lighting
- No flash

Pixel values changing with viewing angle of transparent and reflective objects



Camera

As with taking any photograph there is trade-off between each camera function, desired image attributes and the shooting conditions

Lens

Focuses the light onto the sensor

- Low distortion is desirable. Good quality lenses distort less.
- Sharp (in focus) images are needed. Fixed lenses are sharper.

Aperture

The size of opening allowing light onto the sensor.

- Larger = more light, meaning lower ISO values can be used for a given shutter speed
- High ISO values produce random noise which interfere with the point matching process
- But larger aperture = lower depth of field, meaning the object may not be fully in focus

Larger f-stop number = smaller aperture. F8 is generally the sharpest aperture value unless otherwise stated

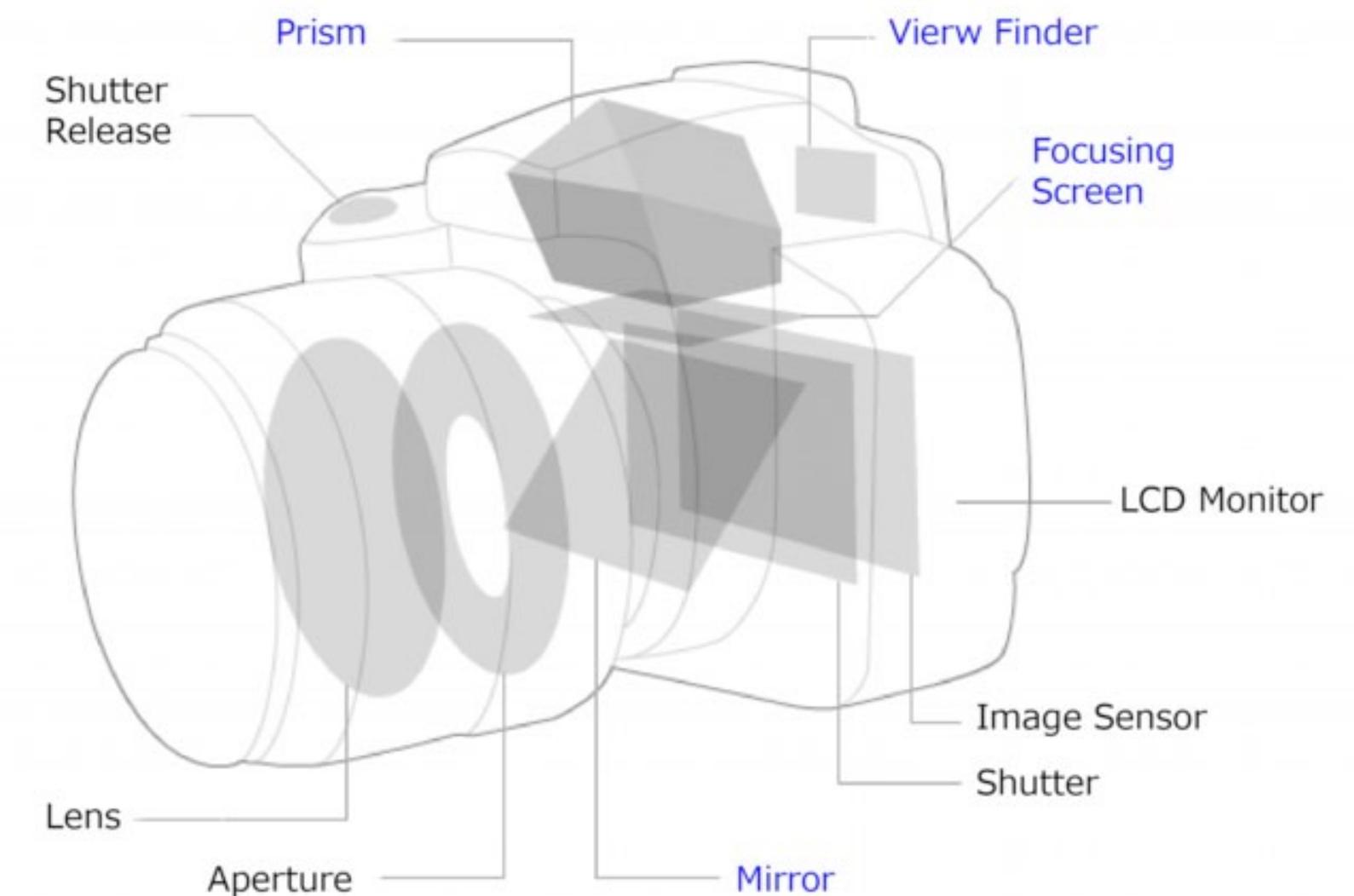
Shutter speed

Determines exposure time

- Longer time = more light, (again resulting in lower ISO), but with more chance of motion blur occurring.
- A tripod and remote trigger should be used with long exposure times

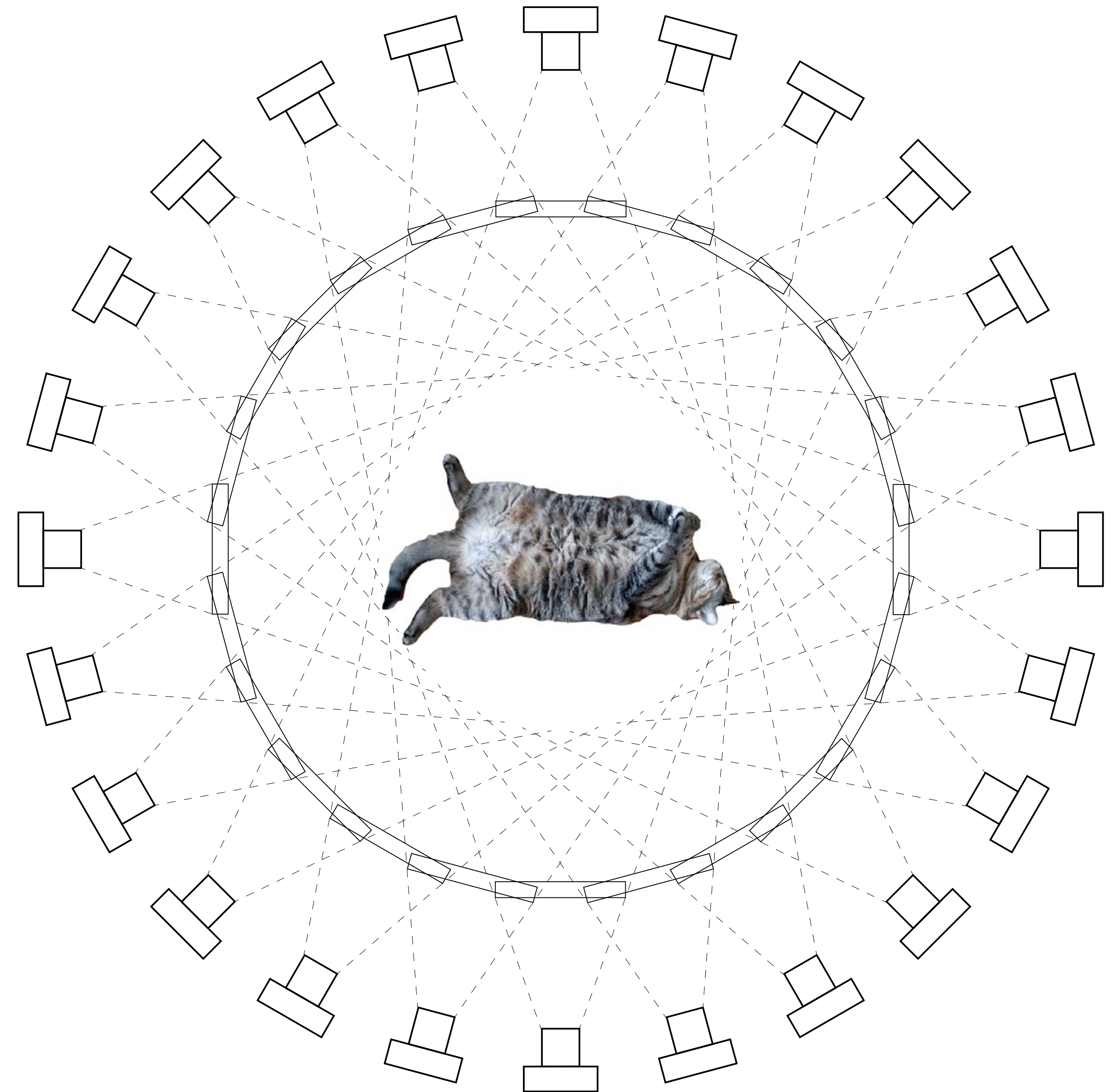
Sensor

- Larger sensors collect more light per unit time meaning less noise
- Does the sensor interpolate its colour values (answer: probably)?



Shot Methodology

- Use a tripod and remote trigger
- DSLR Camera on Av mode (aperture priority)
- Start with ISO 100 (lowest noise)
- Start with f-8 (or if known the sharpest f-stop of lens model)
- Allow camera to calculate shutter speed based on ISO and aperture
- If this speed is unacceptable increase the lighting level, or the aperture/ISO
- If movement is a possibility the model may not build anyway, but: compromise with combination of ISO and aperture increases to achieve a fast shutter speed at least 1/30s
- Each image requires an overlap of 10-30%
- This means taking photos at 5-15 degree angles, or 30-70 photos per revolution
- At least two revolutions of full-frame shots
- The more photos the more detailed the model
- Overlap pairs of images for detailed closeups
- If the lens is known in Adobe Camera RAW, lens correction can be used on all photos, otherwise do not process the photos at all.



Making a model from a set of photos

Agisoft Photoscan is the most commonly used software in the professional photogrammetry industry.

The Slade has one standard license which is enabled on Mac I6 in the DS.

You can download a 30-day trial version which you can use at home or on location to see if your photos stitch together:

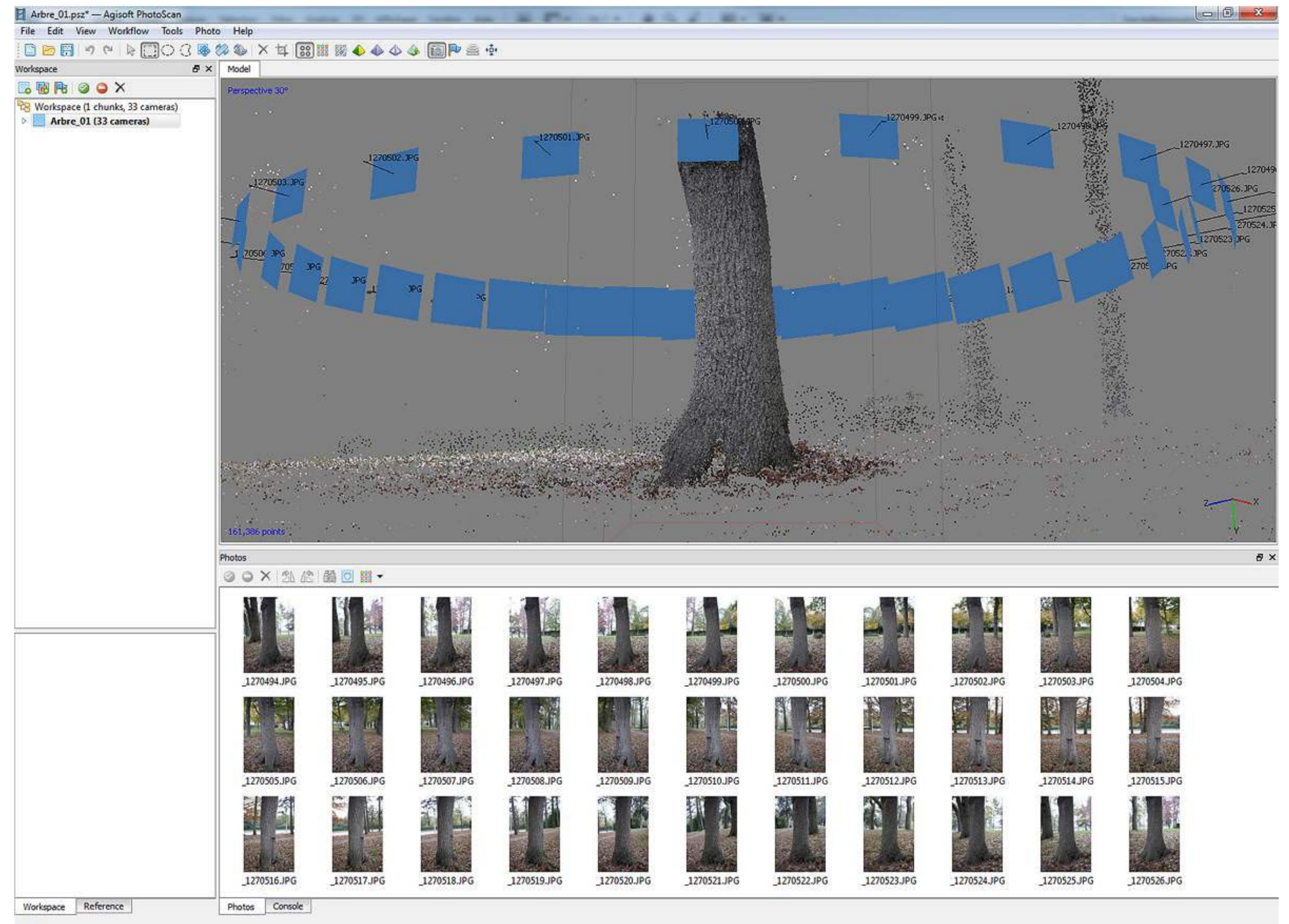
<http://www.agisoft.com/downloads/>

It is quite simple to use, but a good walkthrough including a practice image set is available here:

https://docs.google.com/document/d/ILpjvdMbaeZcFj_PRXPdQByhLnIg-MkoILPX3ITYEYtU/mobilebasic

For a detailed BSc level course on the principles of photogrammetry, the University of Bonn lectures by Cyrill Stachniss are excellent:

https://www.youtube.com/watch?v=_mOG_IpPnpY



PhotoScan

3D Modeling and Mapping