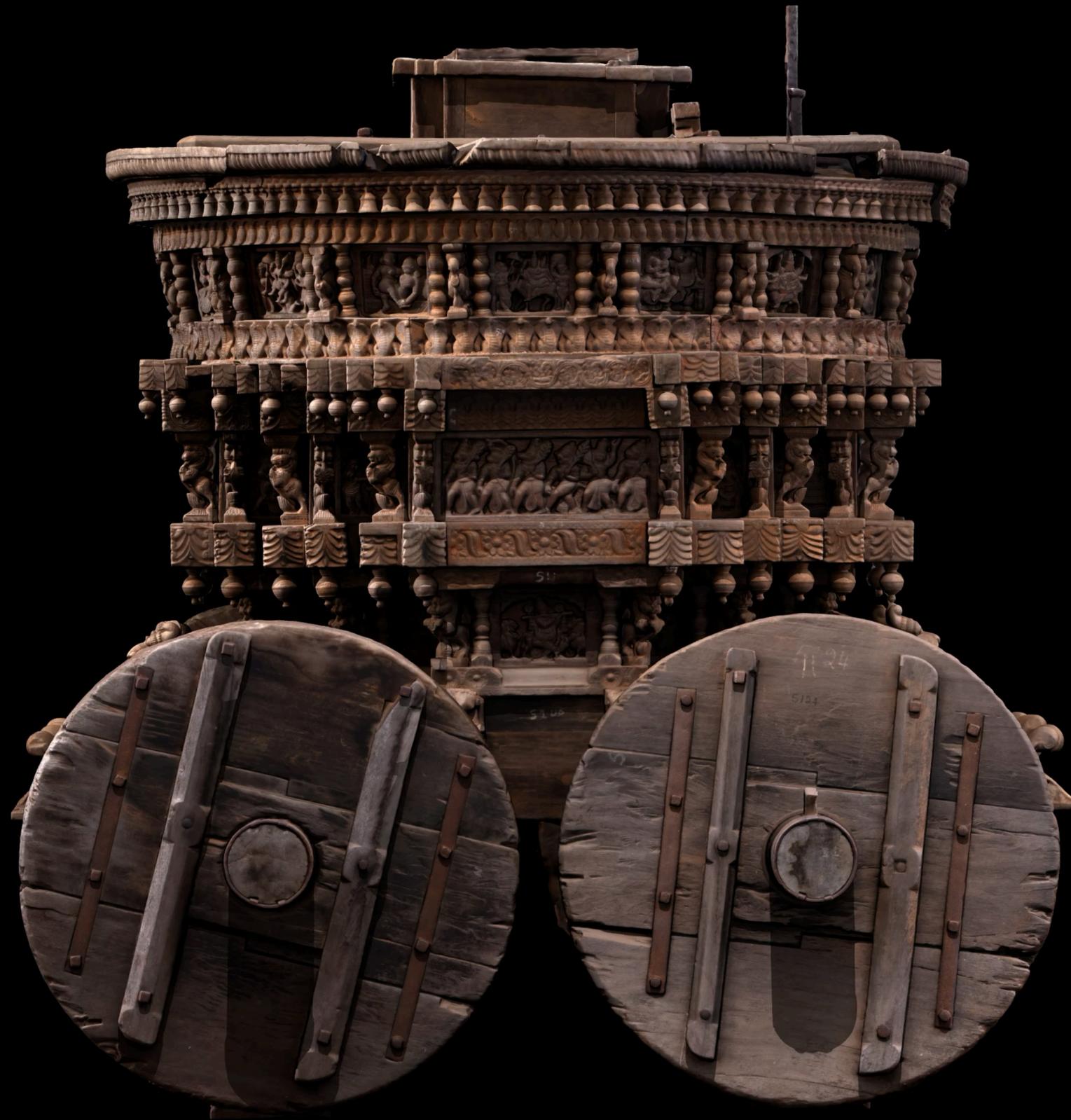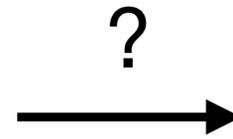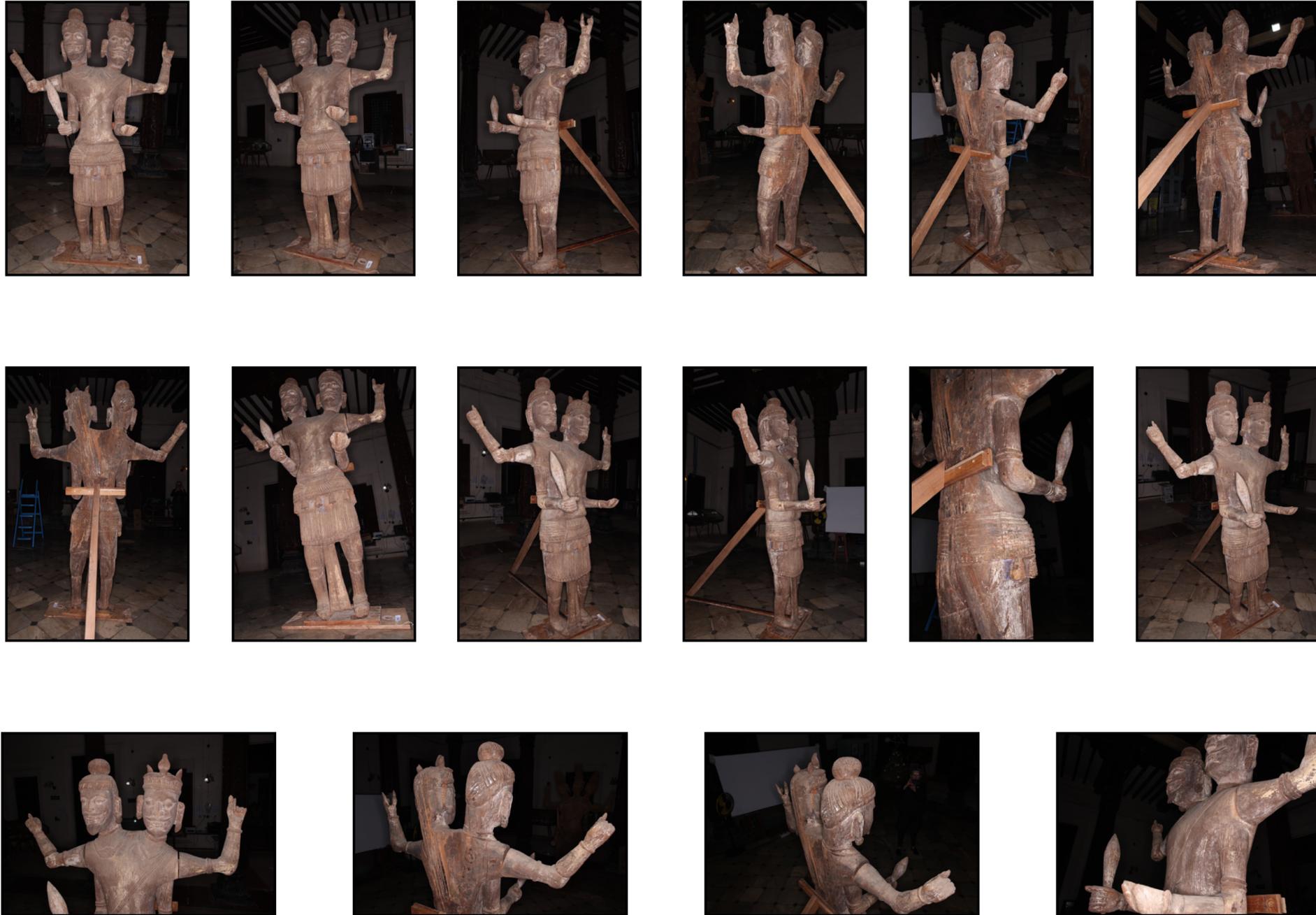# Photogrammetry of Bhuta models

JVM (Jayalakshmi Vilas Mansion) museum in Mysuru (Mysore)

Photogrammetry

3D model data overview

- 25 models in total

- All supplied to scale (m)

- Consistent orientation, z axis "up", y axis "forward", x axis to the "right".

- All supplied as OBJ models, can be imported into almost any 3D package

- All processed to a mesh density of between 2 and 4 million triangles

- Single image file 16Kx16K as a texture

- Typically 100-300 photographs per statue, depending on model complexity

- Photogrammetry software: MetaShape Pro

- Cross polarsisation ring light camera system to manage colour and shading

Outline

- Photogrammetry software

- Photography best practice

- Lighting

- Specularity

- Camera rig

- Photogrammetry pipeline

- Export format and specifics of the models

- Geometric vs texture resolution

Not discussed: Other 3D capture methods: Gaussian splats, Lidar, structured light, return of flight …

Photogrammetry software

- Metashape (used for the Bhuta models). Agisoft. (Commercial)

- Realitycapture. EPIC games. (Free / Commercial)

- MeshRoom. Alicevision. (Open source)

- Zephyr. (Free for small models). Regard3D (Free), Pix4d …

- Visual SFM, Colmap. (Tools)

- …. a whole bunch of other more discipline specific softwares.

- The principles presented here apply across all solutions.
Different packages support different degrees of automation, degree of adjustment and control of the process, maximum number of photographs …

- Gaussian Splats are a different technology, happy to discuss separately.
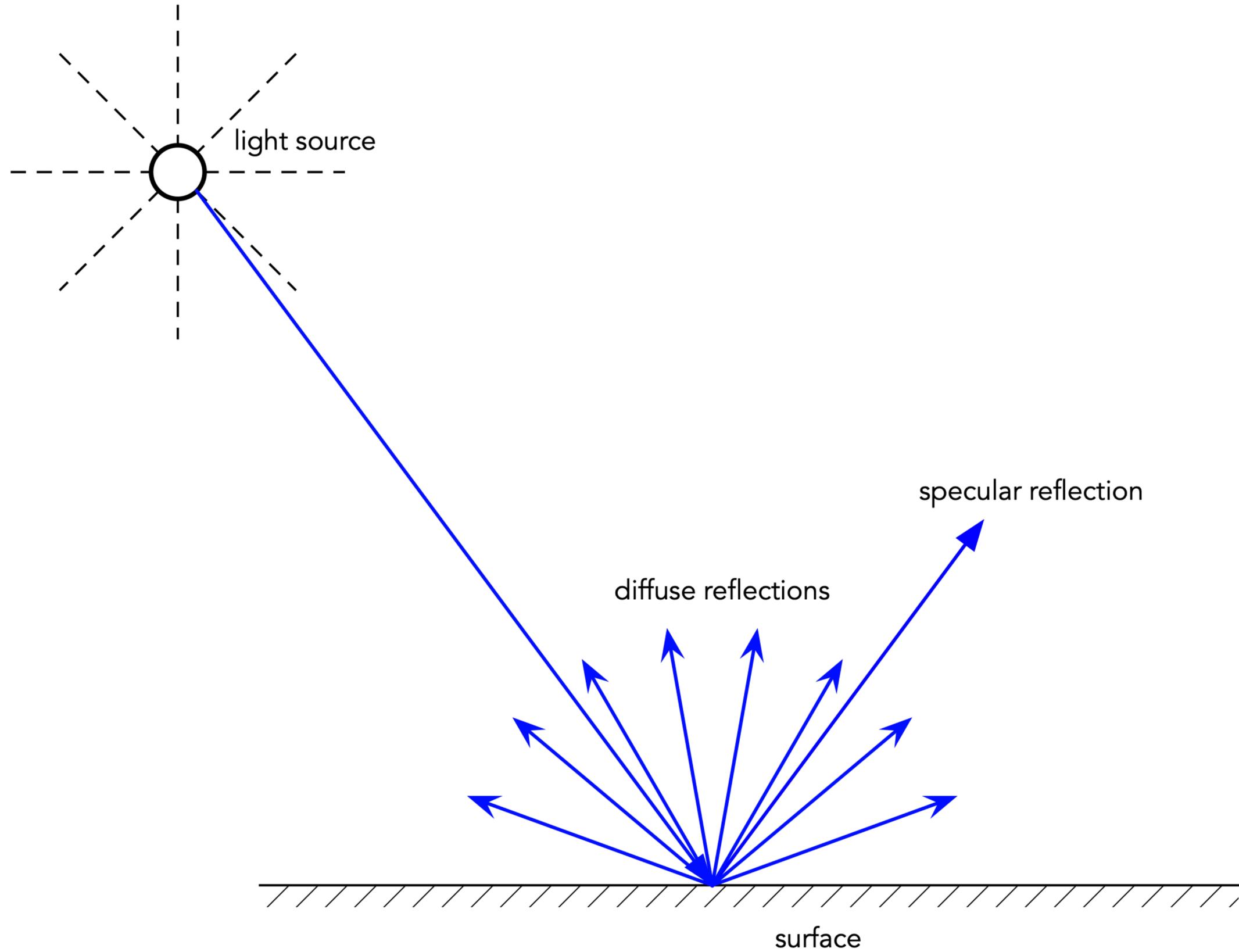
Photography

- One cannot expect parts that aren't photographed to be reconstructed.

- Ideally use all manual settings for iso, exposure time, aperture and white point

- The number of photographs depends on the complexity of the object
  - 2.5D surfaces might only need 10-20
  - For contained 3D objects typically require 50-200
  - Extended landscapes may require 1000's

- Each photograph should be taken from a different location.
  The opposite to panorama photography where camera should be at zero parallax point.

- Camera orientation doesn't matter.

- Focus and depth of focus important.
  Details in the image will determine the number and quality of feature points and eventual texture.

- Best results with a single focal length, eg: Prime lens.

Lighting

- If one uses environmental lighting then shadows will be baked into the model
  - Cannot (easily) relight the model later.
  - Colours can no longer be correct due to shading.

- To remove environmental lighting use a (bright) light adjacent to the camera lens, eg: ring light

- What is the correct colour of a surface?
  The perceived colour (reflected spectrum) depends on the light source spectrum.

- For colour control use a light with a known temperature, high CRI (colour rendering index) value.
  Typically use sunlight, temperature of 5600 Kelvin.

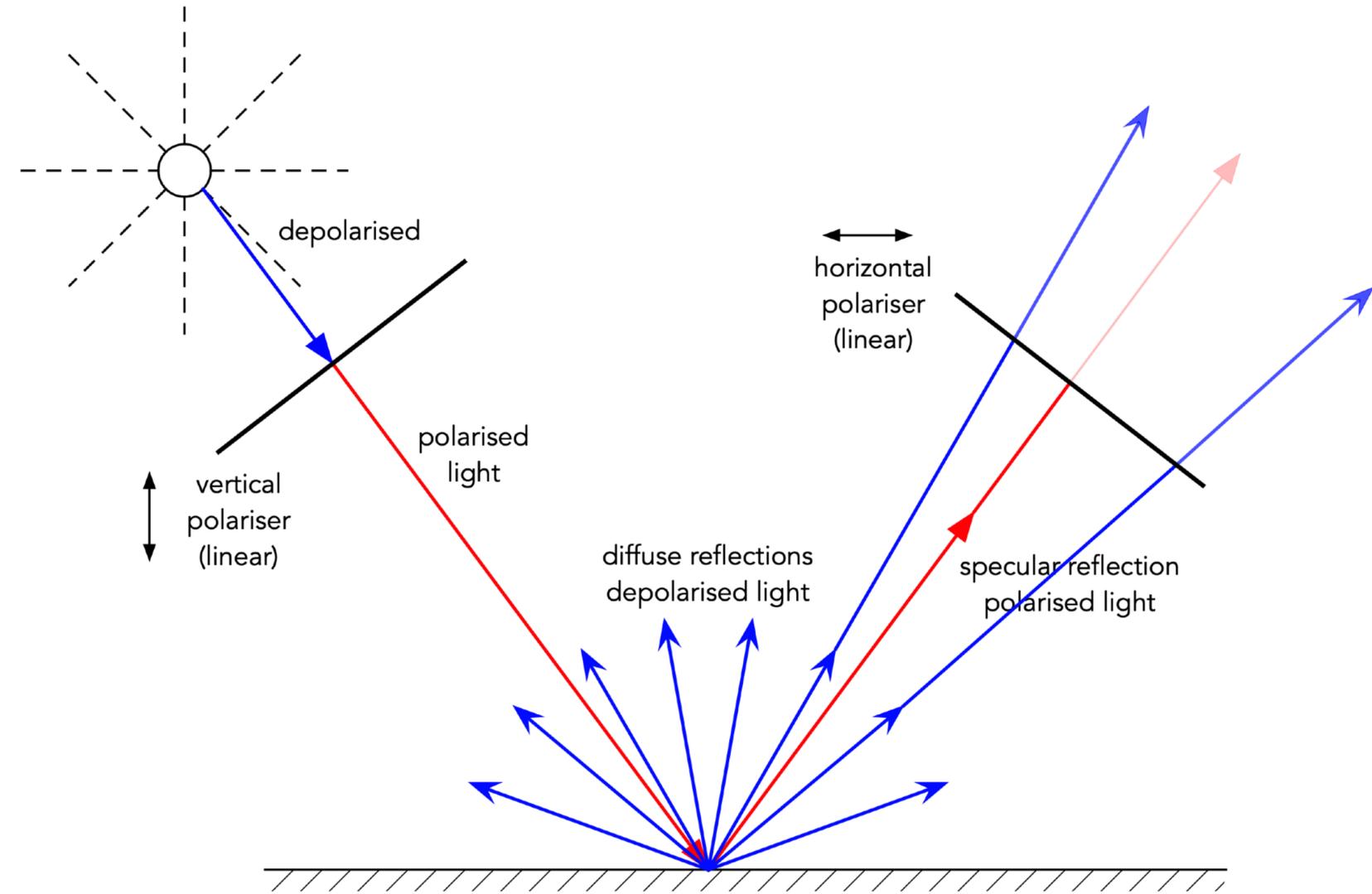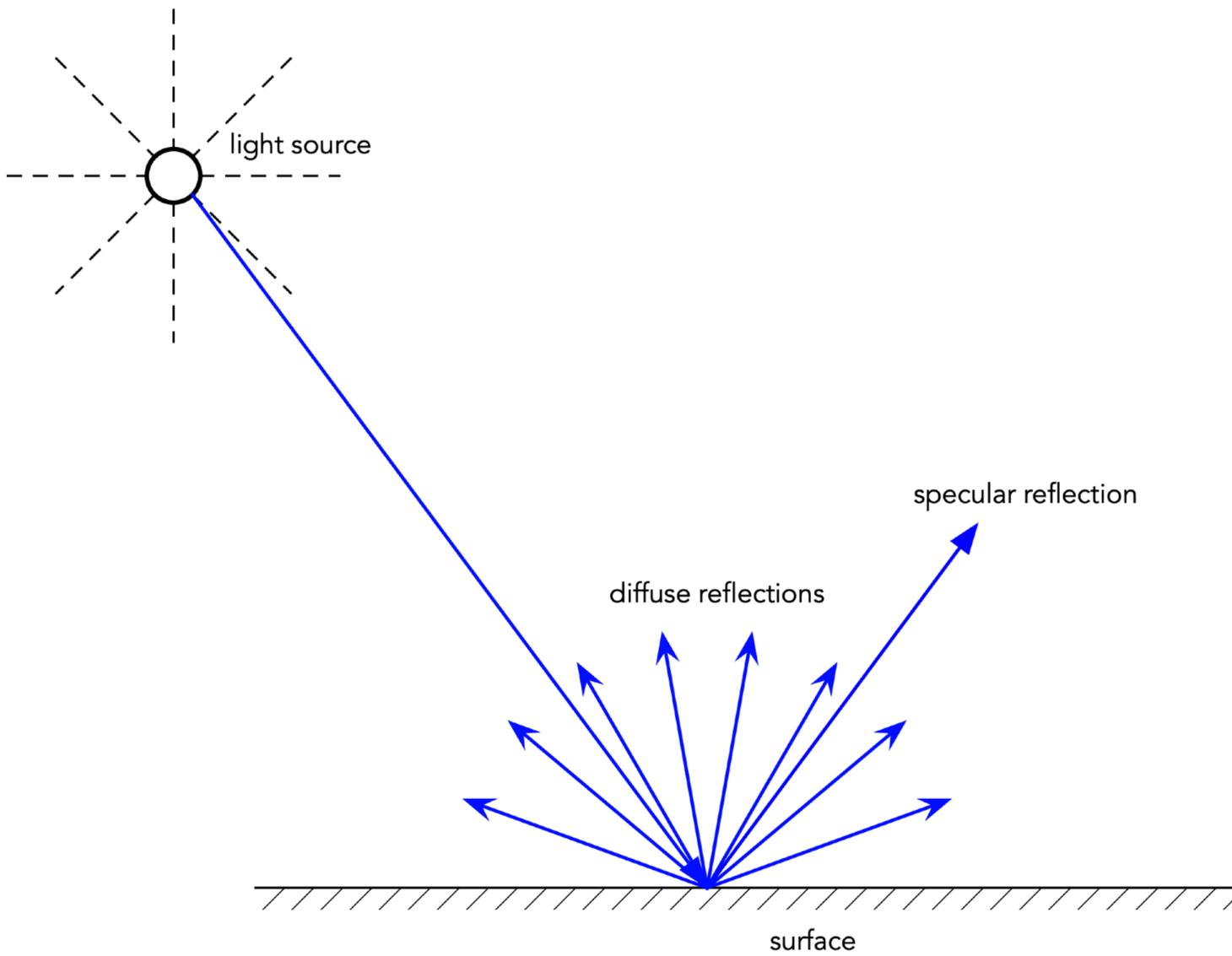- Specular highlights shift with the relative light and camera position.

  Lighting is not a characteristic of the model itself!

Diffuse vs specular reflections

light source

specular reflection

diffuse reflections

surface
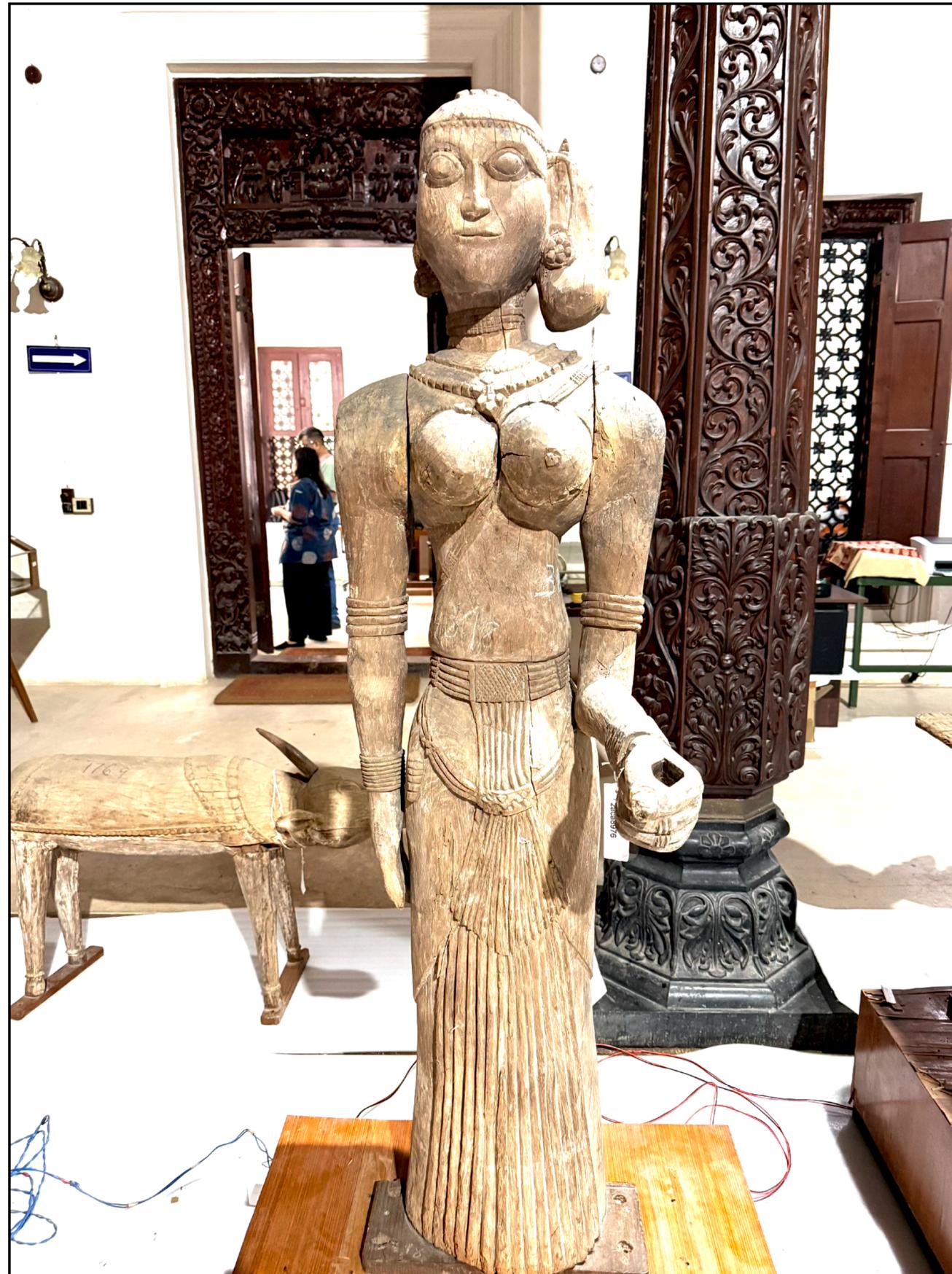
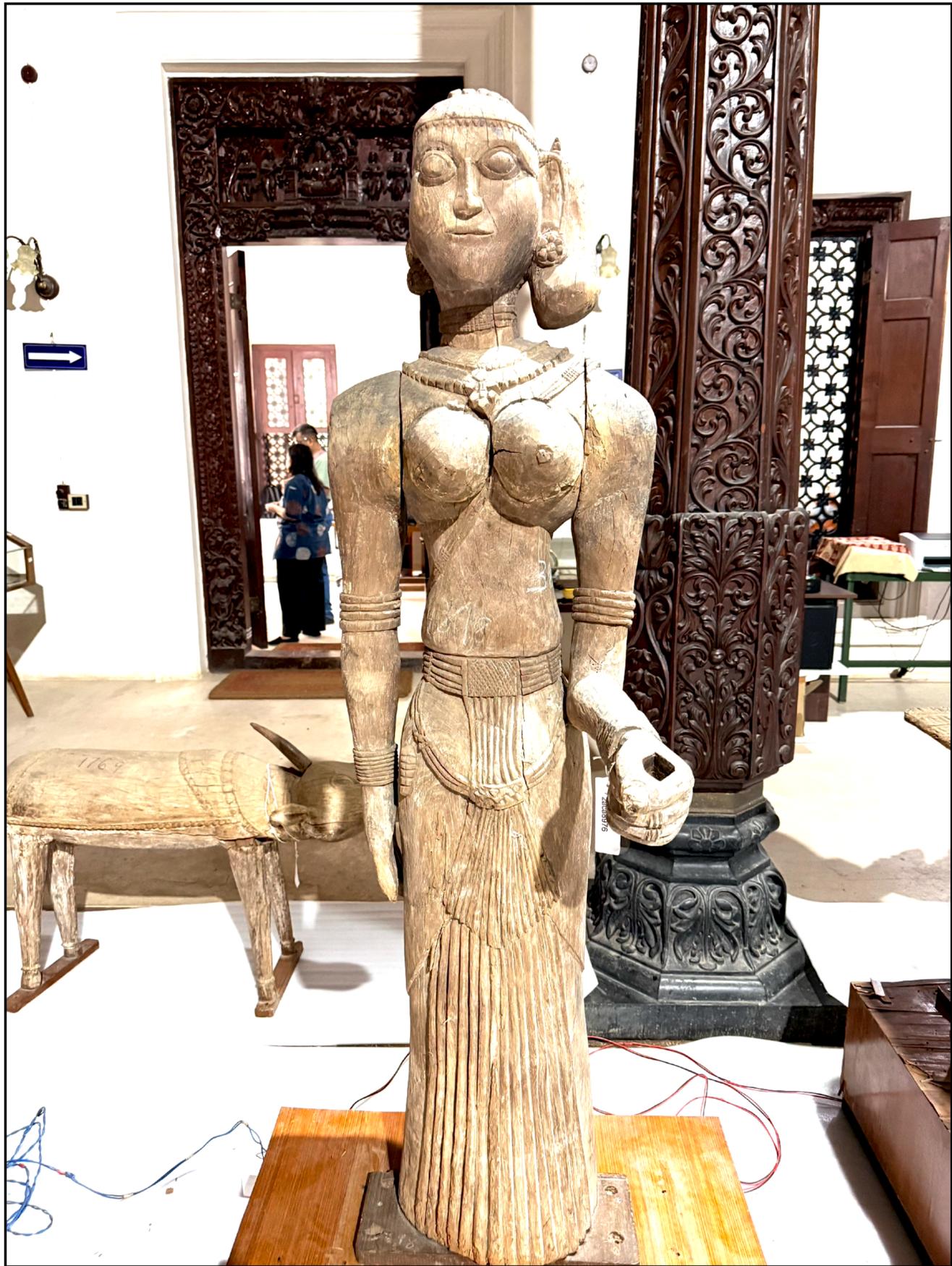# Cross polarisation to remove specular highlights

Camera rig

Polaroid filter on lens

Polaroid filter on light

Pipeline

- Take photographs, each from a unique position, every point on the model should be in at least 4 photographs. Apply colour correction.

- Find feature points between the image, estimate camera position+pose and point cloud using Bundler algorithm.

- Create 3D mesh after calculating depth maps.

- Map photographs from camera position/pose onto mesh forming a texture map.

- Edit and otherwise clean up the mesh
  1. remove "shrapnel"
  2. close holes, eg: base or after (1)
  3. apply scale
  4. perform any other geometric edits
  5. apply edits to texture maps

- Export as favourite 3D mesh format.

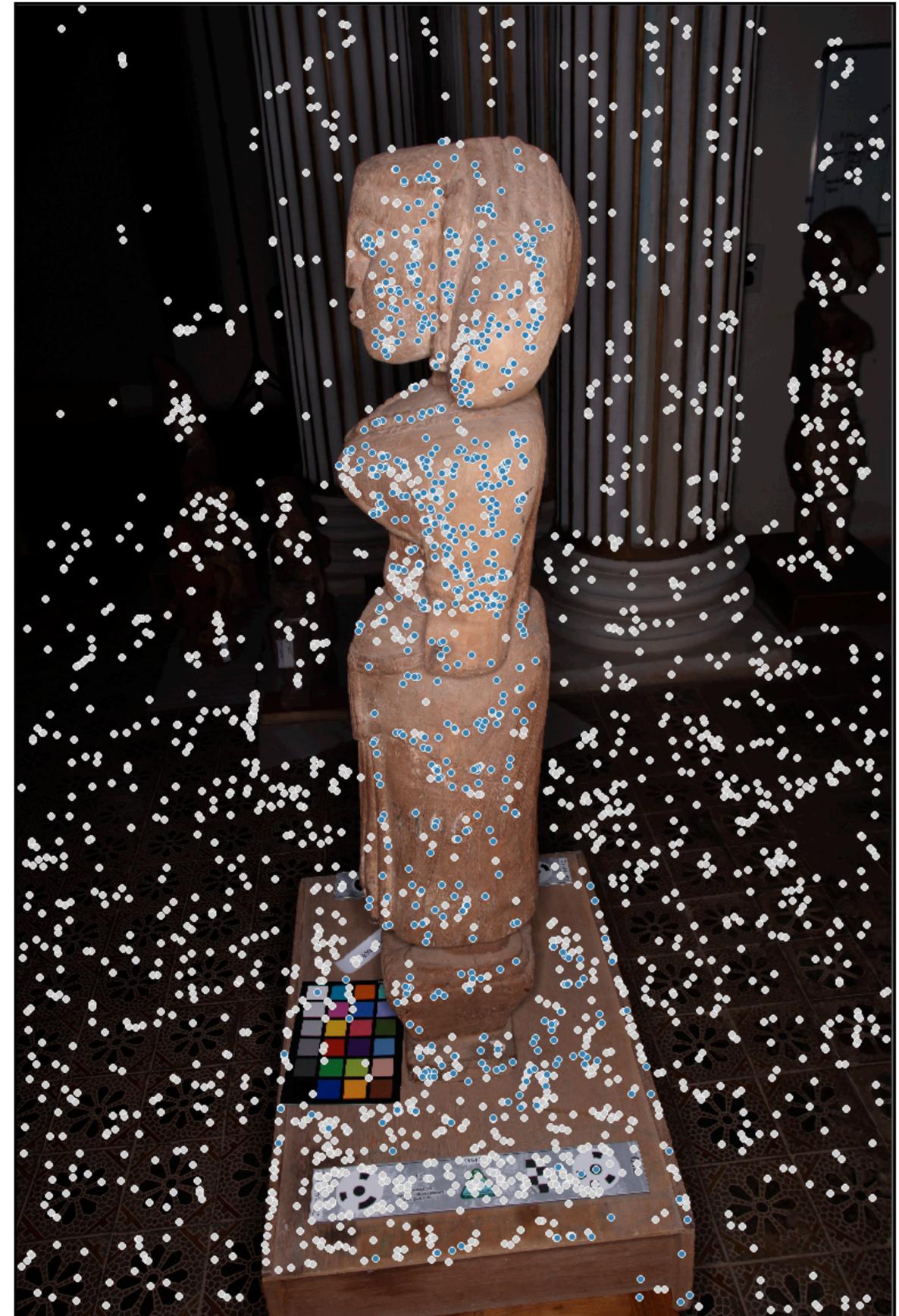# Photography

- Example using model 636b0b67

Photographs

- Include scale rule and colour swatch

- In this case 140 photographs

- Capture RAW files and later convert to 16 bit tiff after performing colour corrections.
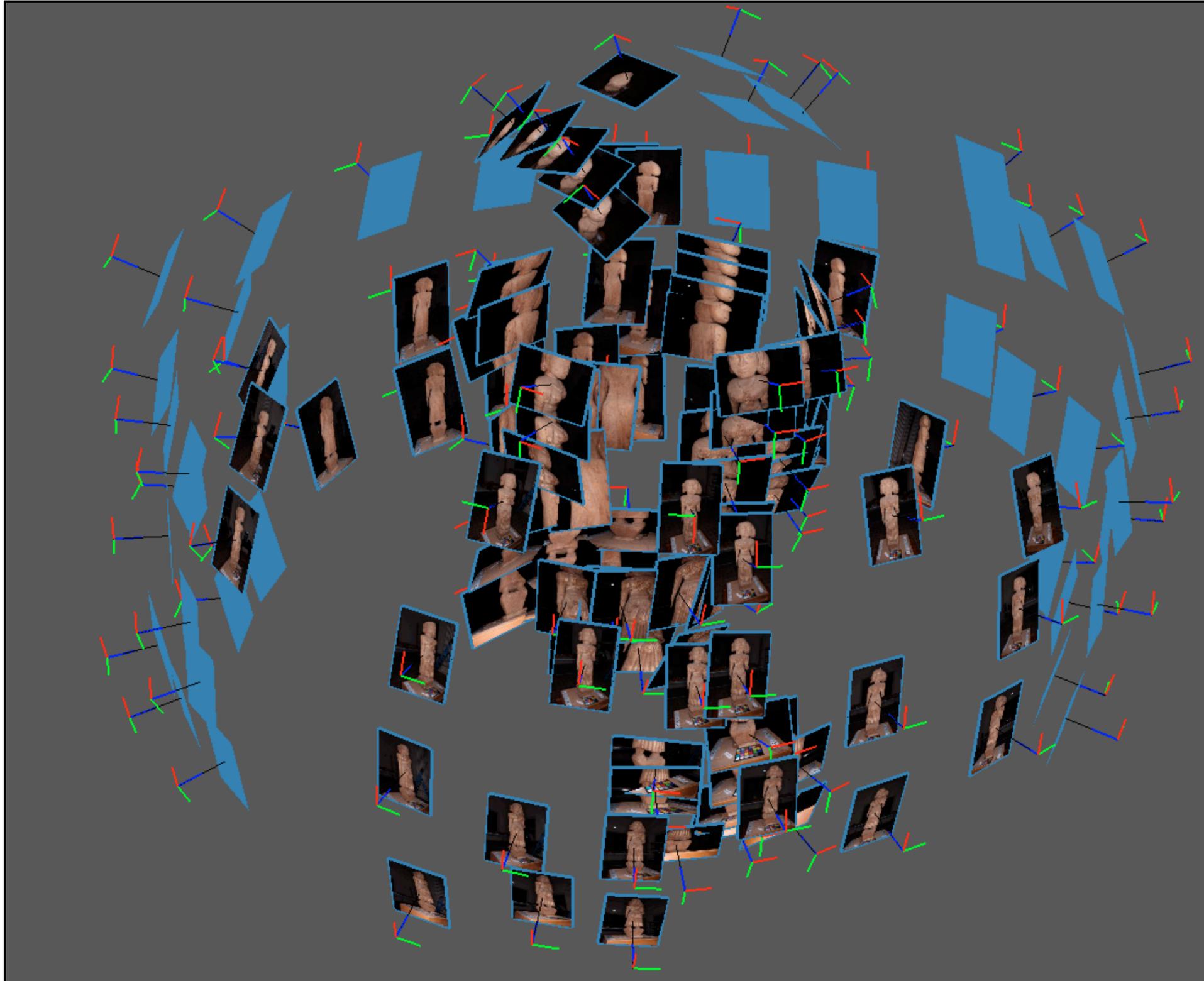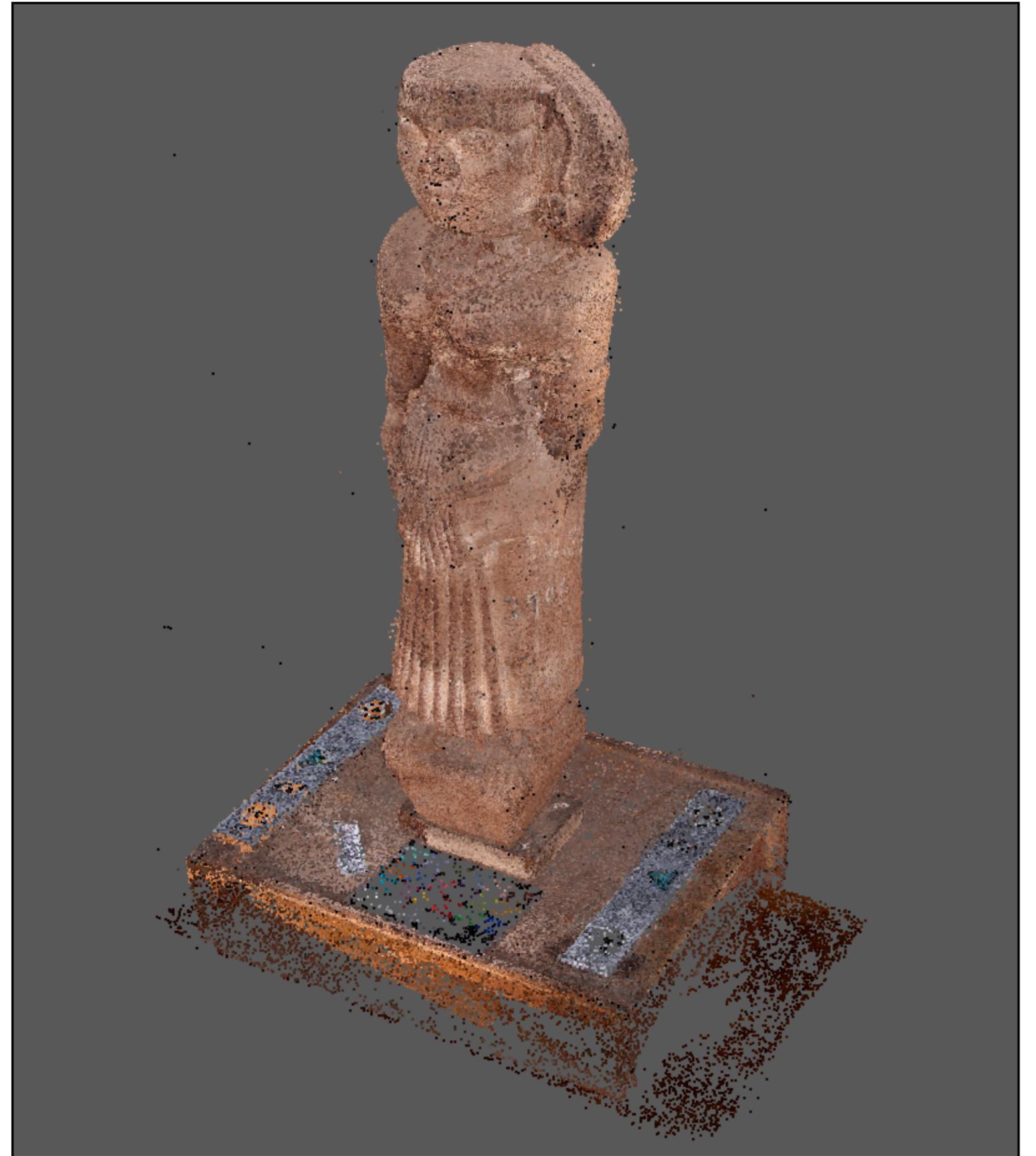
Derive feature points

- Feature points are points in the photographs determined to be the same between photographs.

- This is a core machine vision algorithm.

- Tie points (in blue) are feature points determined to be common to 3 or more photographs.

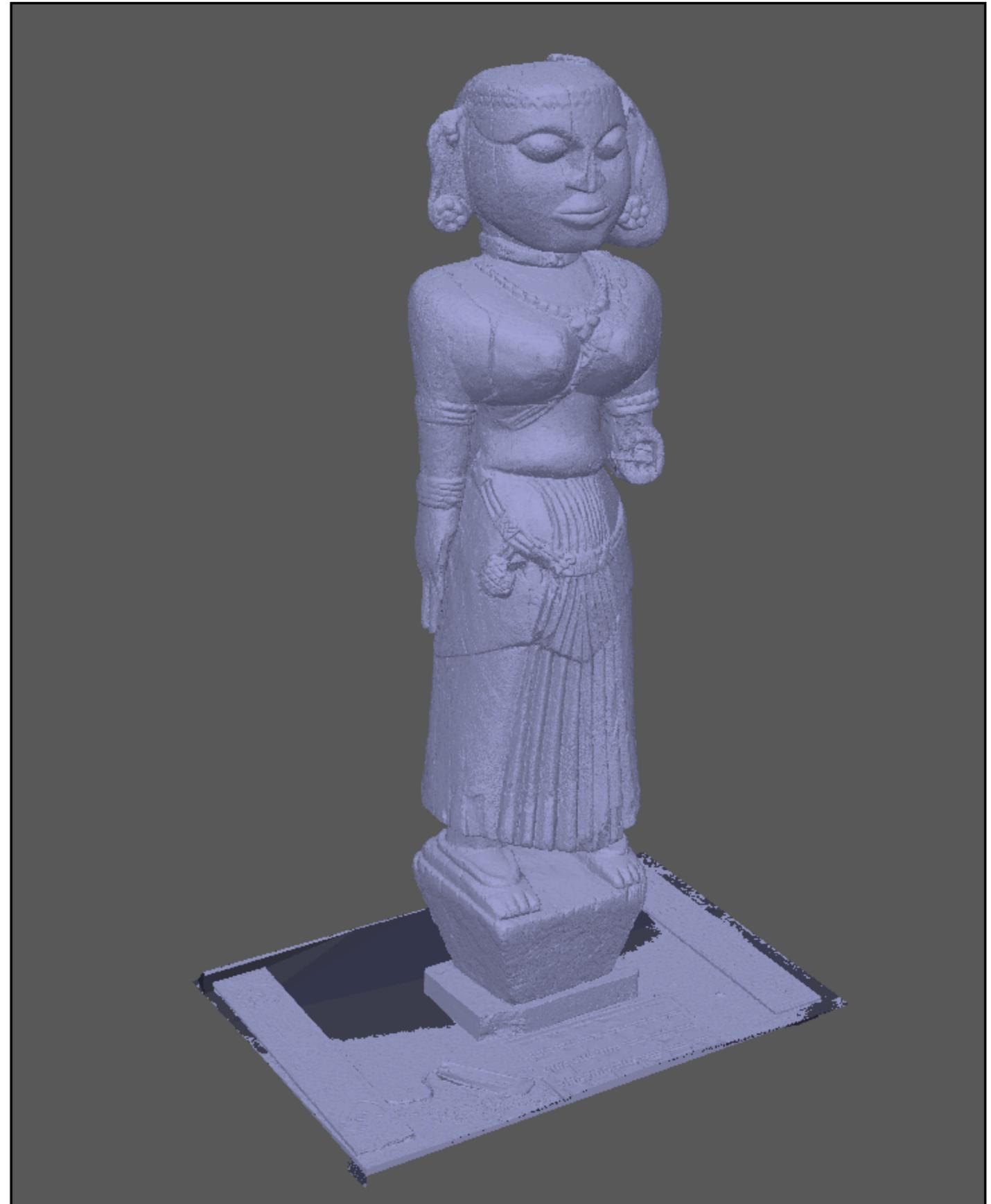# Compute camera positions and pose

Compute point cloud

Depth maps

- Given tie points and camera locations one can triangulate to estimate depth for each point.

- There is a depth map created for every photograph.

Form 3D mesh

- Combine all the depth maps

Apply scale

Clean up

- Metashape has some mesh cleaning/edits tools
  - shrapnel selection and removal
  - hole filling
  - smoothing noise
  - decimating mesh

- Almost any 3D modelling package can be used, common choices include:
  - Blender, good for remeshing to a regular mesh
  - Zbrush, good for smoothing
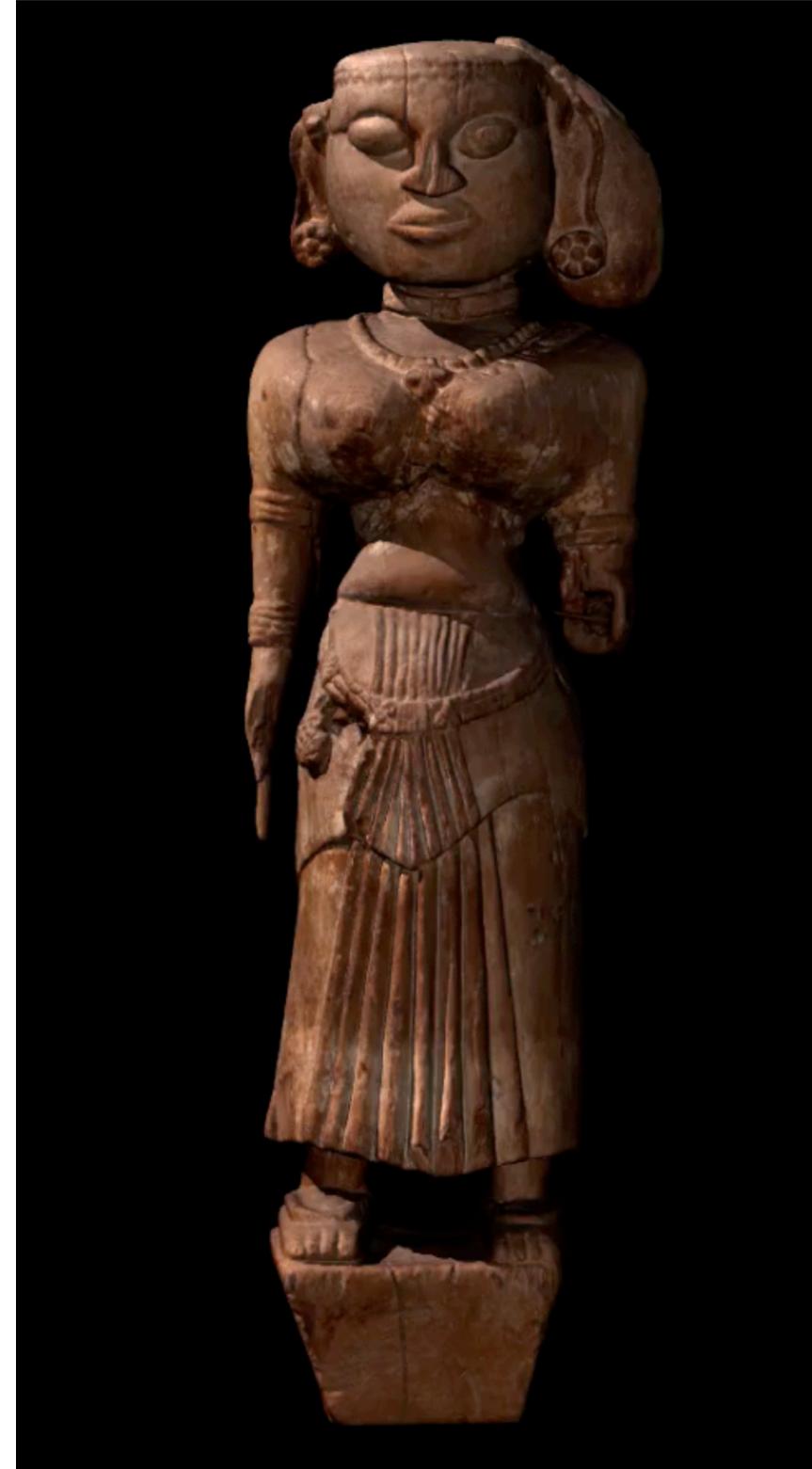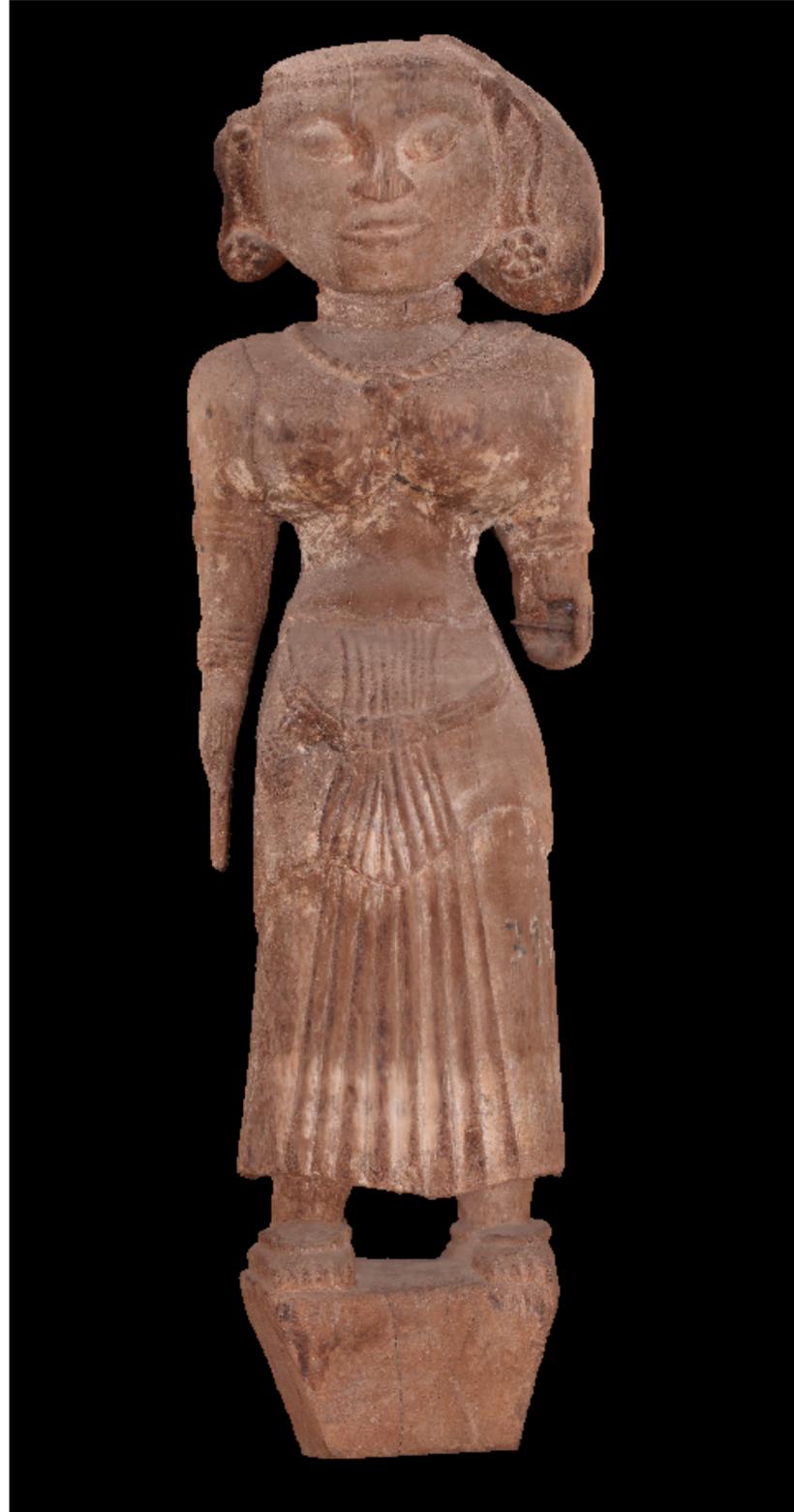 - Meshlab

Apply texture maps

Edit textures

- Optionally remove old numberings written directly on the statue.

- Remove other tags, cobwebs, dust/dirt …

Consequence of lighting

Export 3D model

- Will use OBJ format here, simple and software agnostic.

- An old format but widely supported.
  The base format for import into other software and more sophisticated formats.

- Typically comprises of 3 files
  - .obj file, this contains the geometry as vertices, normals, texture cordinates, faces
  - .mtl file, material file creating the mapping between texture in the .objfile and texture images
  - One or more texture images

- The Bhuta models here are exported as meshes with between 2 or 4 million faces (depends on the model complexity) and a single 16K texture image.

636b0b67.obj   636b0b67.obj.mtl   636b0b67.jpg
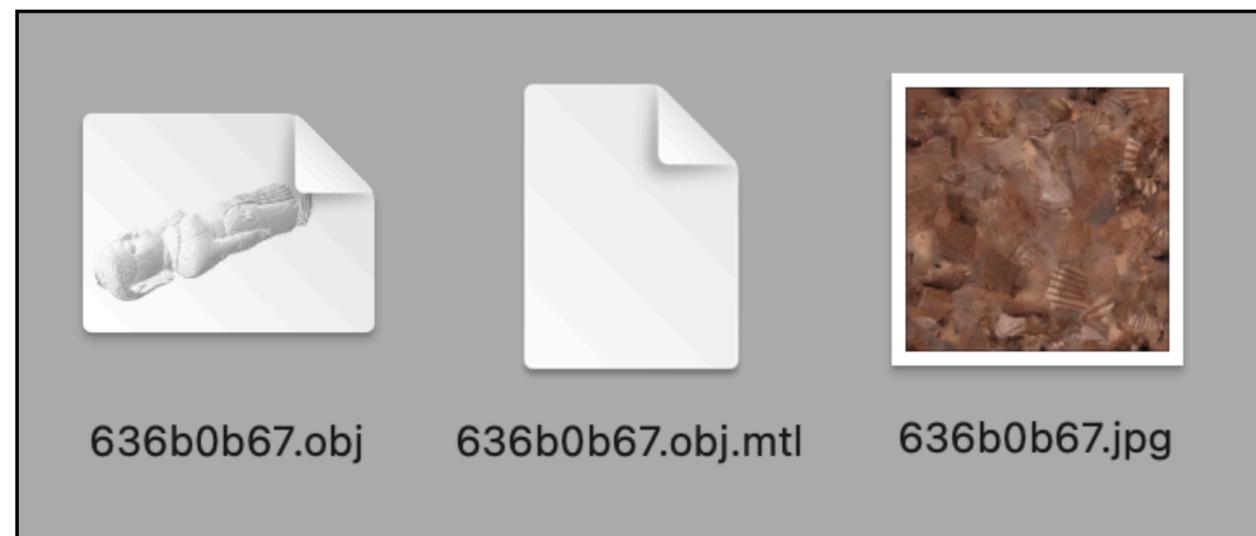
Alignment

- Models from photogrammetry are typically arbitrary rotated.

- Alignment of Bhuta models includes
  - Center at the origin
  - Rotated such that "z" axis is up
  - Rotated such that "y" axis is forward

- Performed in MeshLab
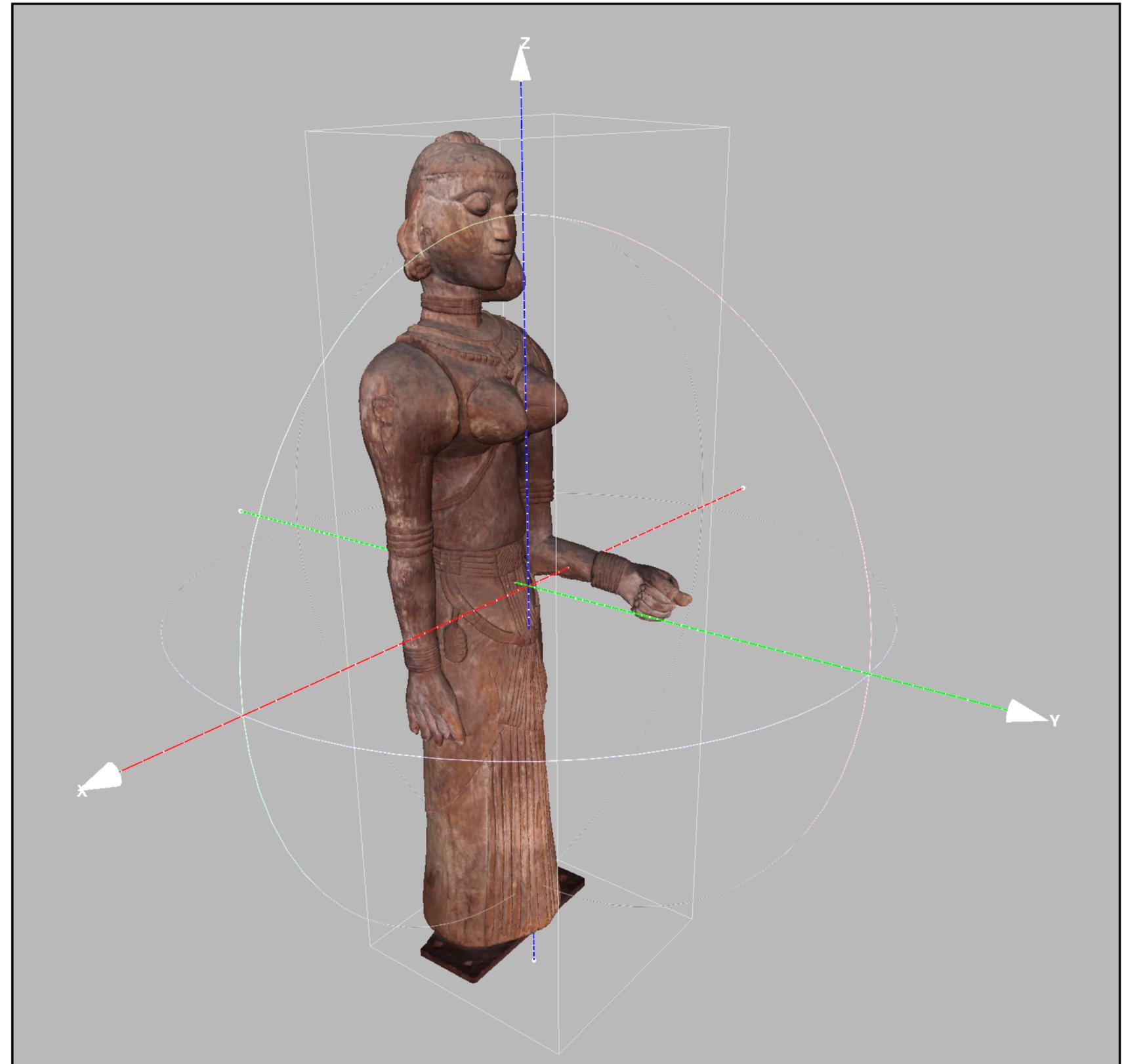
Geometric resolution vs texture resolution

- Geometric and texture resolution are two separate considerations.

- For example, for realtime graphics one might prefer (or require) low geometric resolution and higher texture resolution.

- For analysis one may prefer high geometric detail.

- For archiving purposes one generally wants to maximise both.

- Resize textures in a paint program, eg: PhotoShop (Image size)
  Resample mesh in a 3D program, eg: MeshLab (Quadratic edge collapse, with texture)
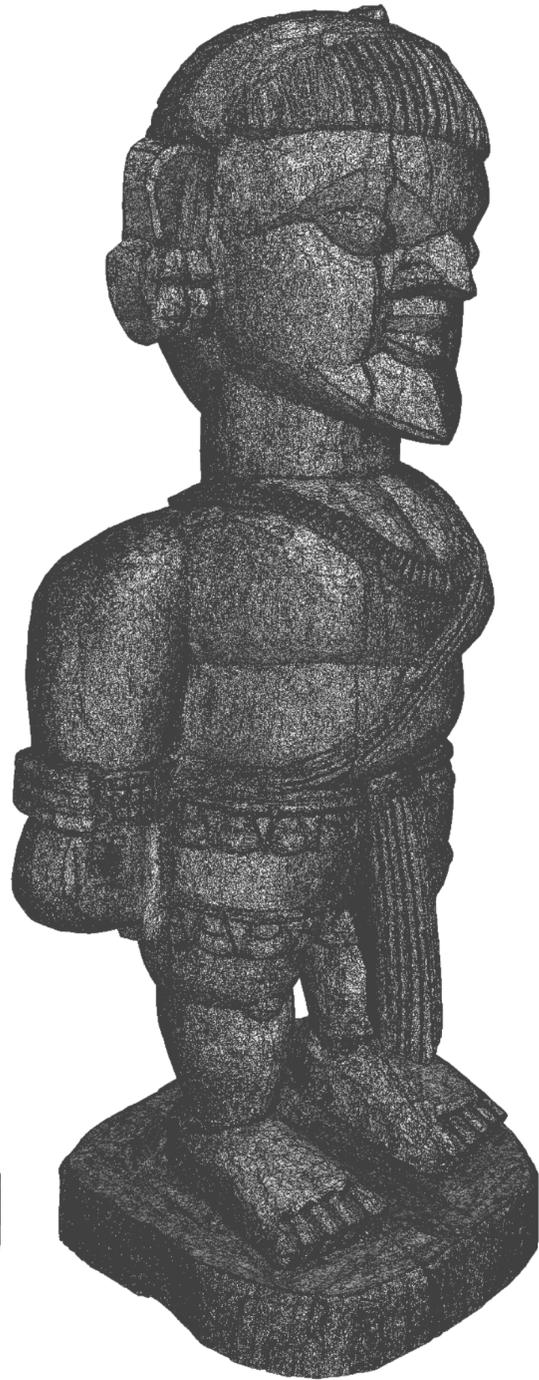
Good textures can often hide low geometric detail.
Always evaluate the quality of photogrammetric models by viewing without texture maps.
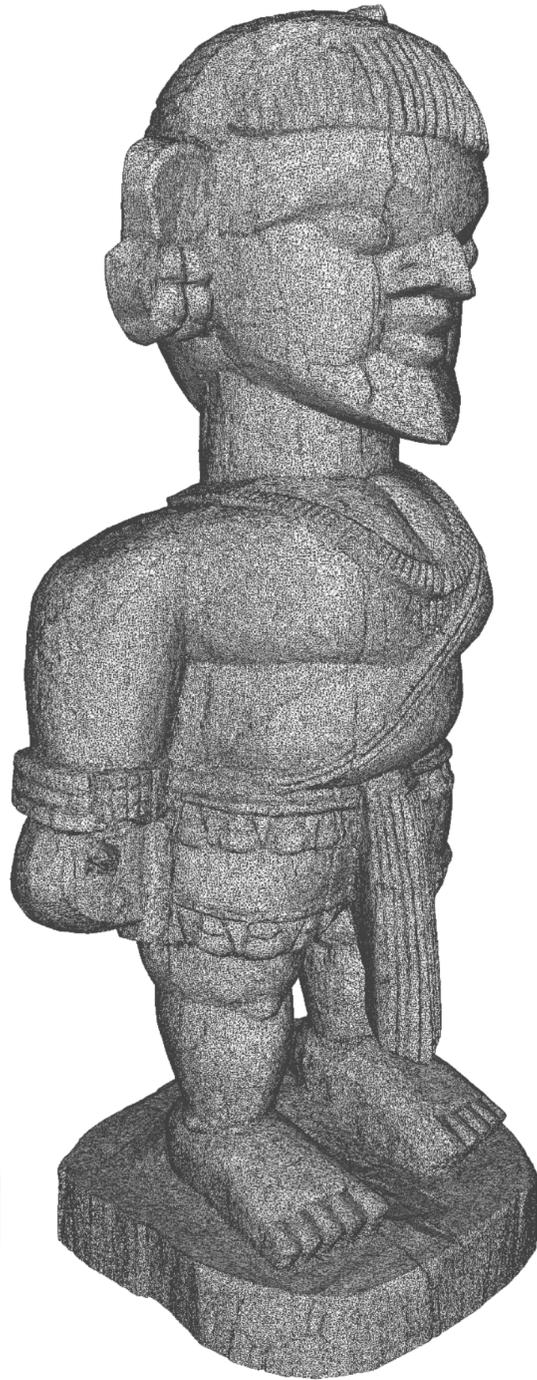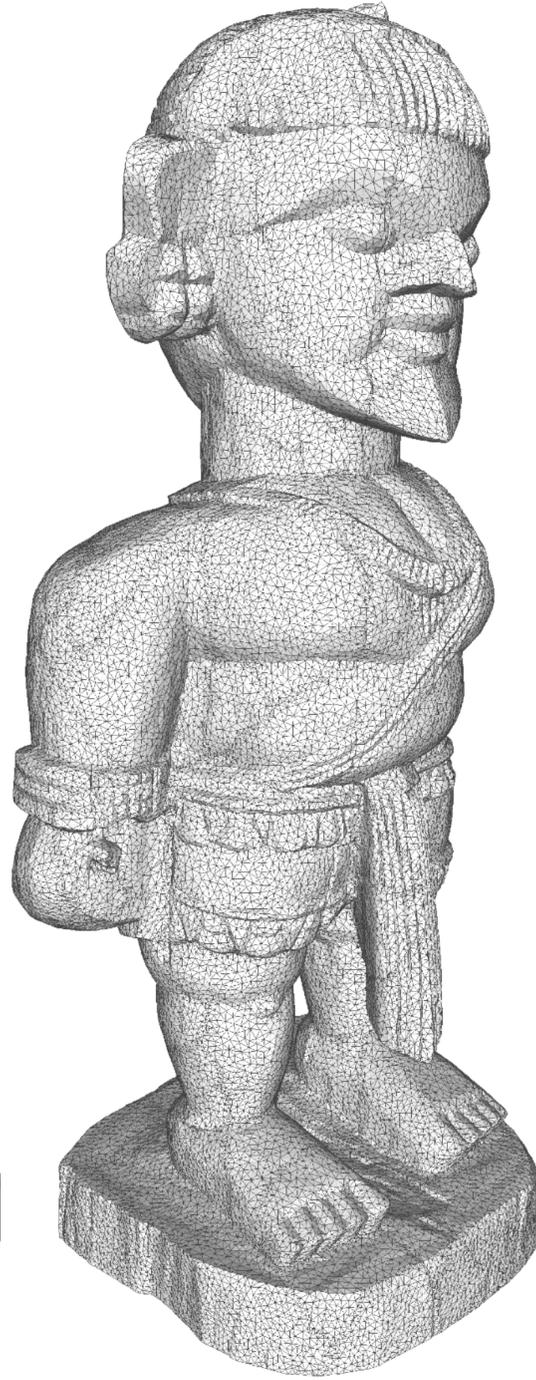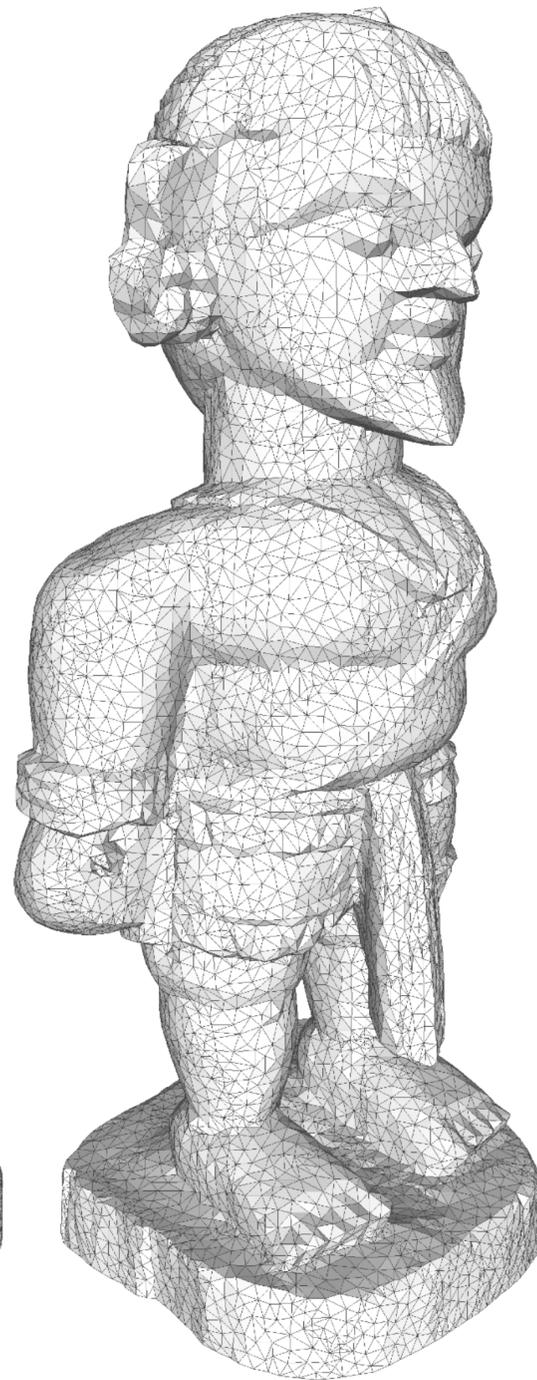
Textured	Wireframe	Wireframe	Wireframe	Wireframe	Textured
3 million triangles	3 million	3/4 million	100 thousand	25 thousand	