Photogrammetry

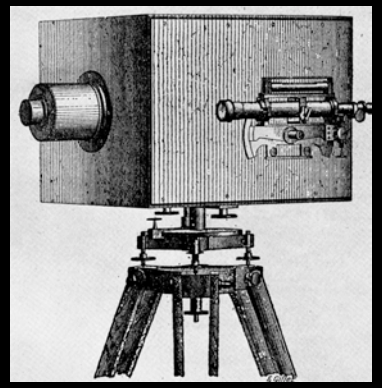
Background and Methodology

Photogrammetry: what is it?

- Image measurement and interpretation in order to derive the shape and location of an object from one or more photographs of that object
- Today it is a computerized process that produces spatial accuracy from photographs
  - Creates an output: map, drawing, measurement, 3D model

(Very) Brief History of Photogrammetry

- 1850s: introduction of the first photogrammetric cameras used for architectural measurement
- 1990s: digital camera, software programs developed to assist in image processing and 3D-modeling



Photogrammetric Camera, 1852

Canon Mark III, 2000s

Why do we practice photogrammetry?

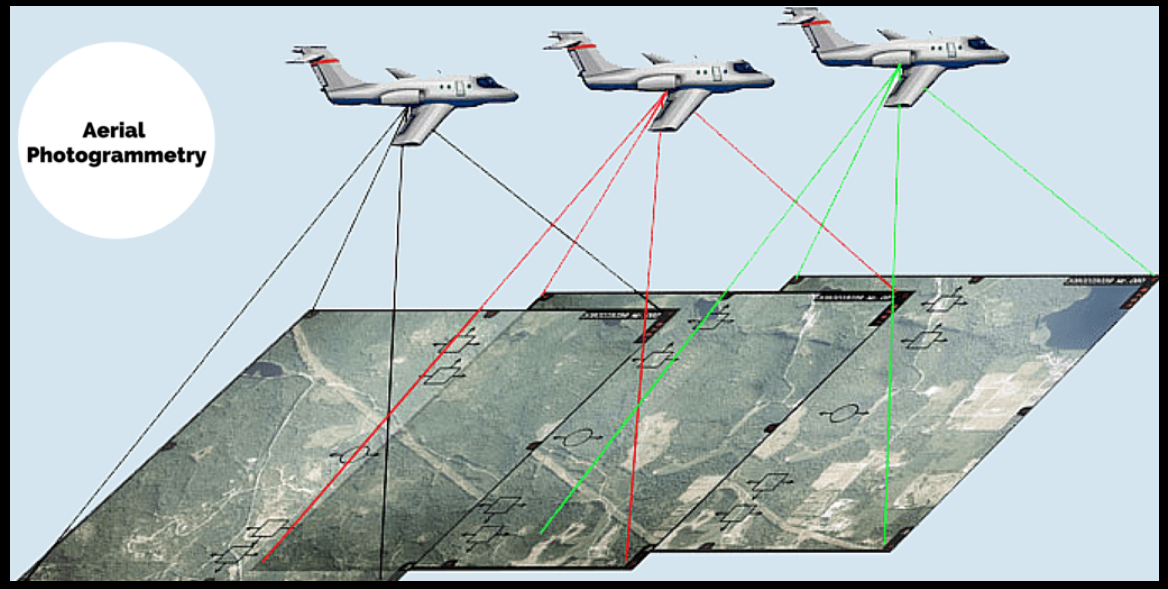
- Obtain accurate renditions of features/artifacts
  - Take measurements from the models because they remove distortion present in 2D photographs
- Cultural Heritage
  - Photogrammetry provides an opportunity to preserve cultural heritage in an electronic format
    - Ex. Assyrian reliefs destroyed by Isis
- Increase public interest
  - Photogrammetry provides an opportunity to “democratize” information and make it available to the public
    - Ex. 3D city models

Types of Photogrammetry

- Aerial Photogrammetry: Plans, Maps, Models
- Field Photogrammetry (Complex subject): Architecture, Contexts, in-situ Objects
- Lab Photogrammetry (Simple subject): Objects, Artifacts

Basic Principles: Aerial Photogrammetry

- Subject overlap
- Photographs can be taken from drones, planes, balloons, etc.
- Spots marked on landscape, GPS coordinates taken and then entered into software to ensure scale



3D Model: Aerial Photogrammetry

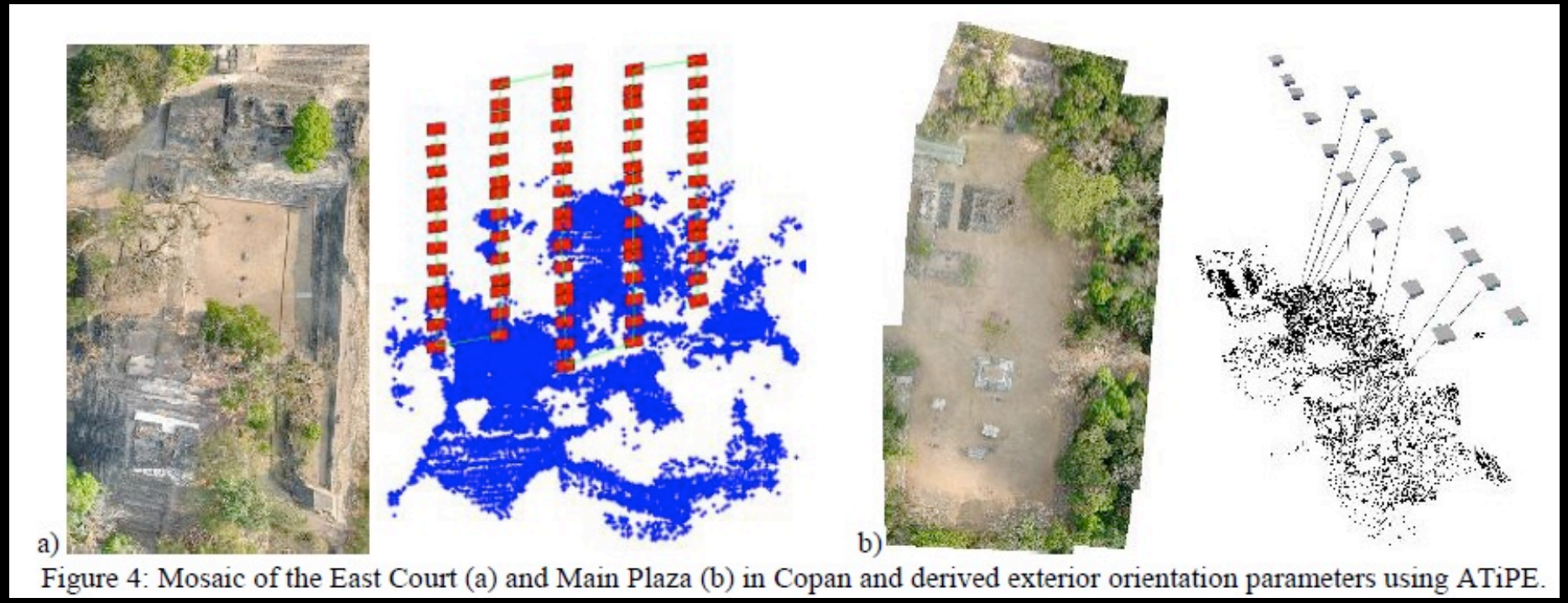


Figure 4: Mosaic of the East Court (a) and Main Plaza (b) in Copan and derived exterior orientation parameters using ATiPE.

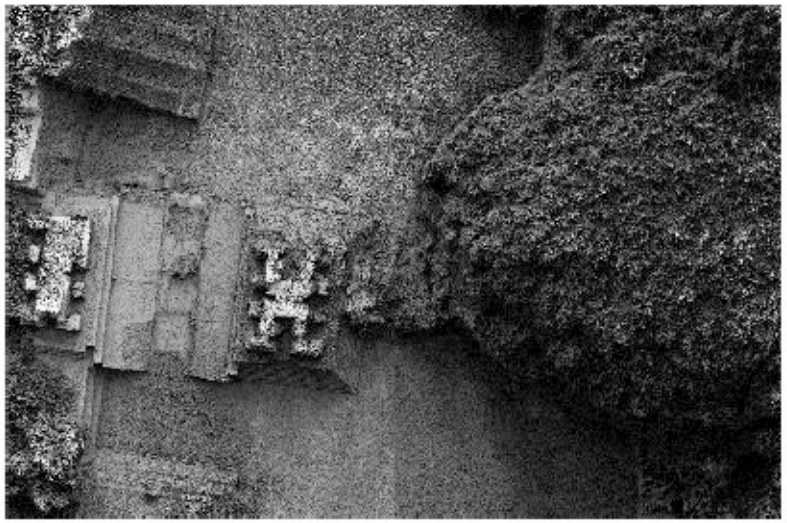


Figure 5: Produced DSM over the entire East Court in Copan (left) and a closer view of the reconstructed Ball Court (shaded and color mode) inside the Main Plaza (right).

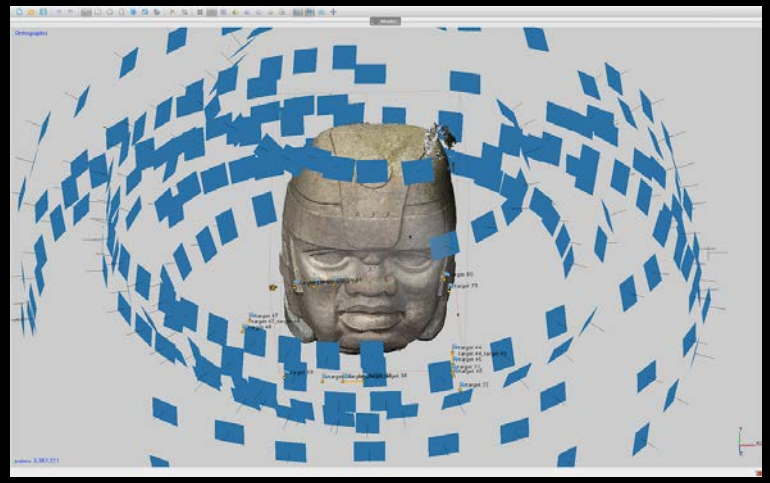
3D Model: On-Site Complex Subject

Orkney Islands: Ness of Brogdar:
https://sketchfab.com/hugoandersonwhymark/collections/ness-of-brodgar-2015

3D Model: Simple Subject

1. Shooting the Object

2. Processing the Model



3. 3D Model in Sketchfab

chi Cultural Heritage Imaging a nonprofit corporation
Helping Humanity Save History

Simple Subject: Lab Set-Up and Model

Key Points

- Important to use a professional camera
- Choose the correct image processing software and follow the appropriate guidelines
  - Many projects do not follow strict guidelines and therefor while their photogrammetric models look accurate (because they are overlain with the photographs) the measurements are not scientifically accurate

chi Cultural Heritage Imaging a nonprofit corporation

Helping Humanity Save History

Photogrammetry…

- ***IS*** the use of photographic data set to accurately measure a subject and use those measurements to create a 3D model.
- ***REQUIRES*** careful, geometry-driven data capture and responsible recording of metadata.
- ***OFFERS*** reliable, testable and reproducible information in an accessible and engaging format.

Good Photography + Good Geometry +
Good Optimization + Good Lab Notebook =
RELIABLE, REPRODUCABLE, SCIENTIFIC MODELS

Stages of modeling of Tlinget helmet. Photo courtesy of CHI.

Digital Lab Notebook

- Ties DIGITAL records to REAL WORLD data.
- Should include any/all contextual information that is not imbedded in .exif data.
- Strong Digital Lab Notebooks include:
  - Equipment used
  - Parties involved
  - Duplicate Records
  - Location information (GPS coordinates)
  - Project Management Information (exhibition, excavation, etc).

Photogrammetry Process

- Capturing the Subject
  - Photography using Digital SLR Camera
  - Capture in the “raw”
- Image Preprocessing
  - Processing images for upload to photogrammetry software
  - Using programs like Adobe Camera Raw
- 3D Modeling
  - Software such as Agisoft Professional
  - Workflow to render accurate model up to 0.0001m
  - Multiple outputs

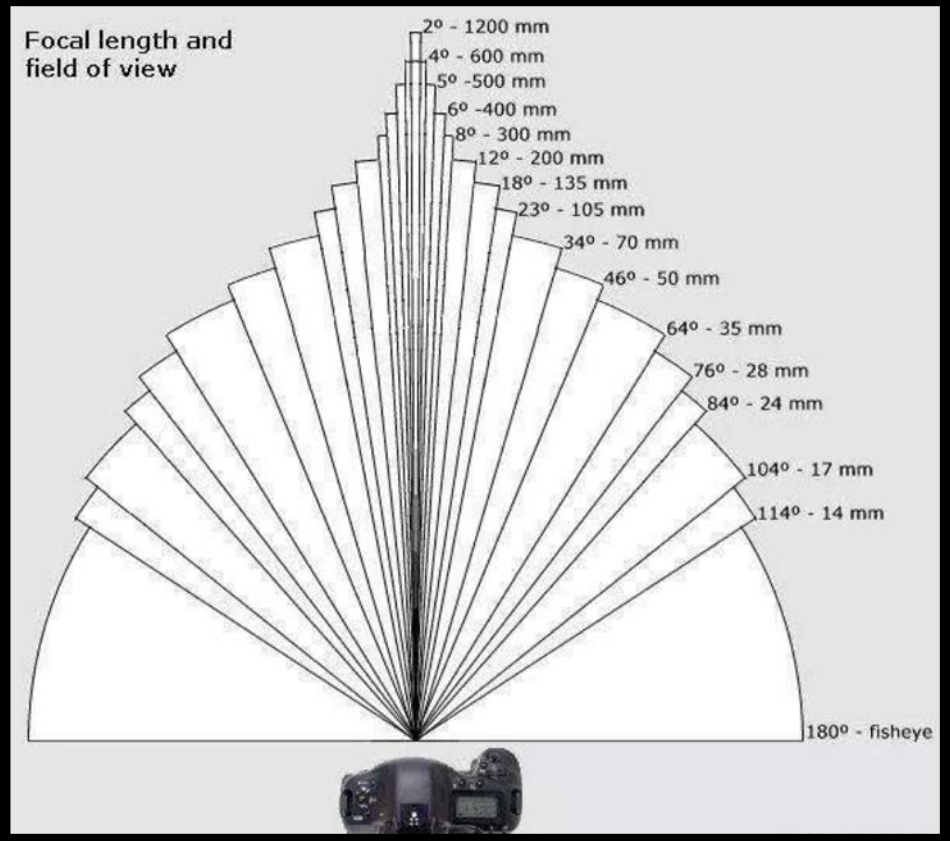
Capturing the Subject

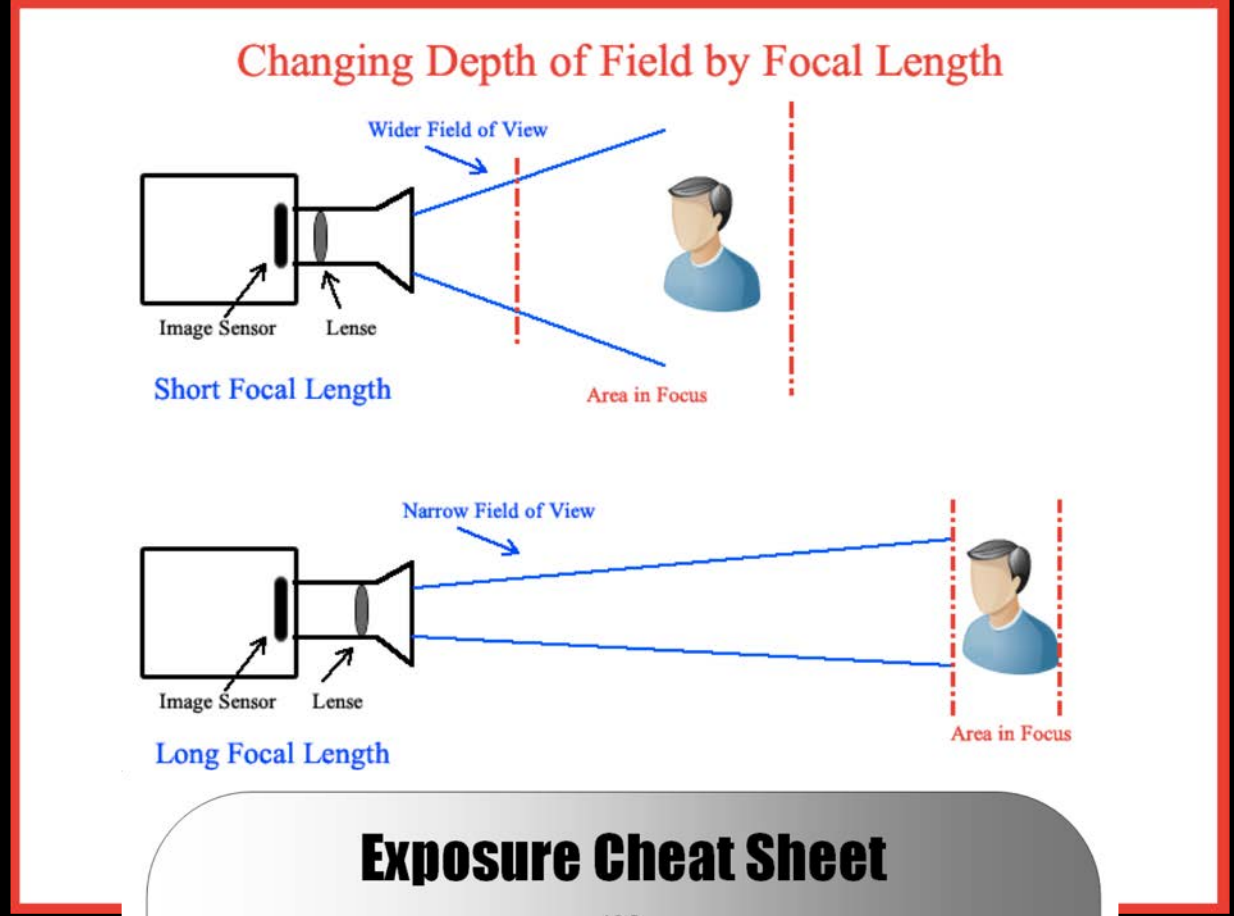
- Good photography
- Overlap of photos***
  - “Good geometry”
- Scale bars
- Color card

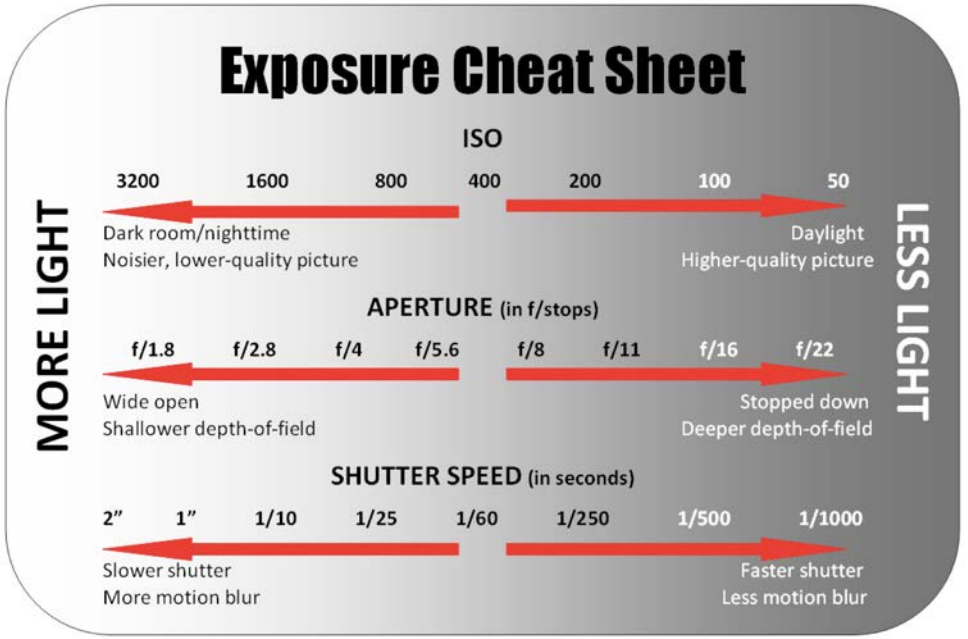
Good Photography

IDEAL SETTINGS:

- Aperture: f/8,
- Shutter: 1/125
- ISO: 100

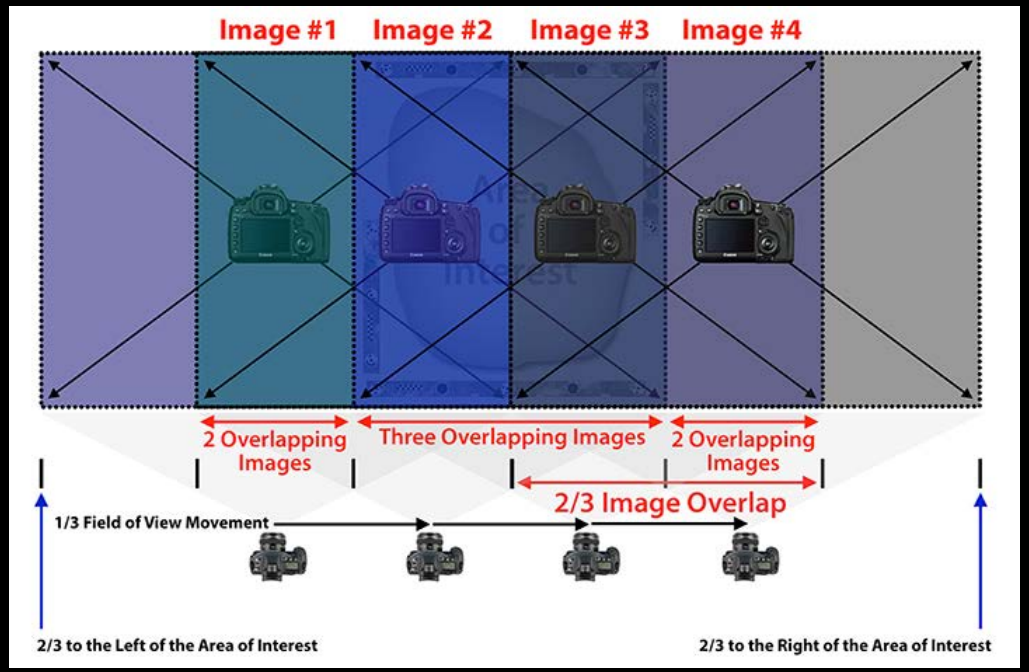




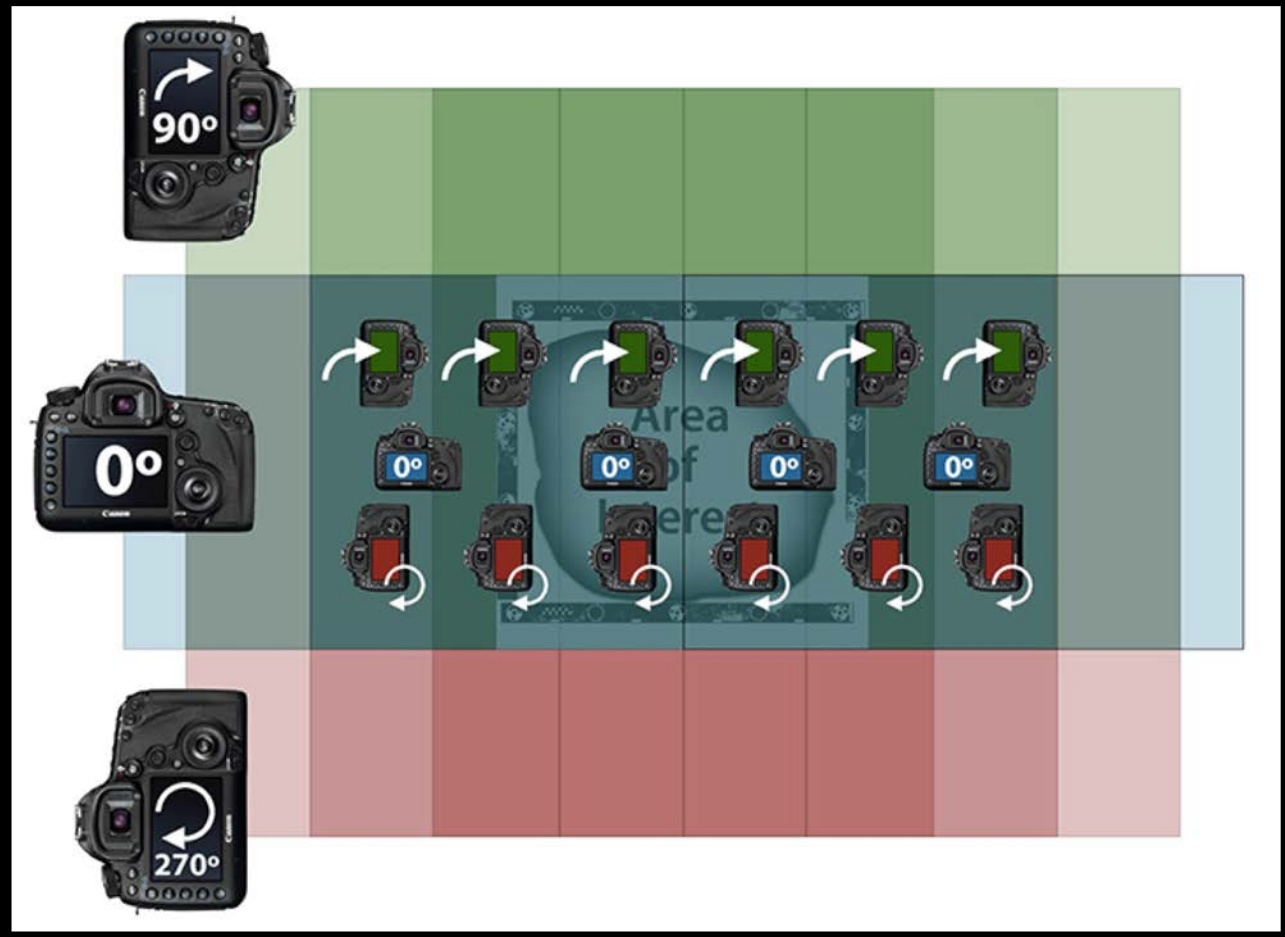


Good Geometry
Basic Principles: On-Site Complex Subject

- 2/3 overlap of photographs on flat subject; 3/4 overlap rounding corners
- Rotate camera to ensure multiple image orientations on camera sensors
- KEY: scale bars for accuracy
  - Color card for color correction



Good Geometry
Basic Principles: On-Site Complex Subject



Set-up: Special Collection College Hall

- Solid background
- Turntable for object
- Lights
- Camera tripod

Good Geometry
Basic Principles: Simple Subject

- Can be done in the lab or in the field
- 360° in the round; 36 photos every 10 °
- Subject on a turntable, 3 angles
  - Straight
  - Top angled down
  - Bottom angled up
- Include a “flat run” with scale bars for accuracy and color card for color correction

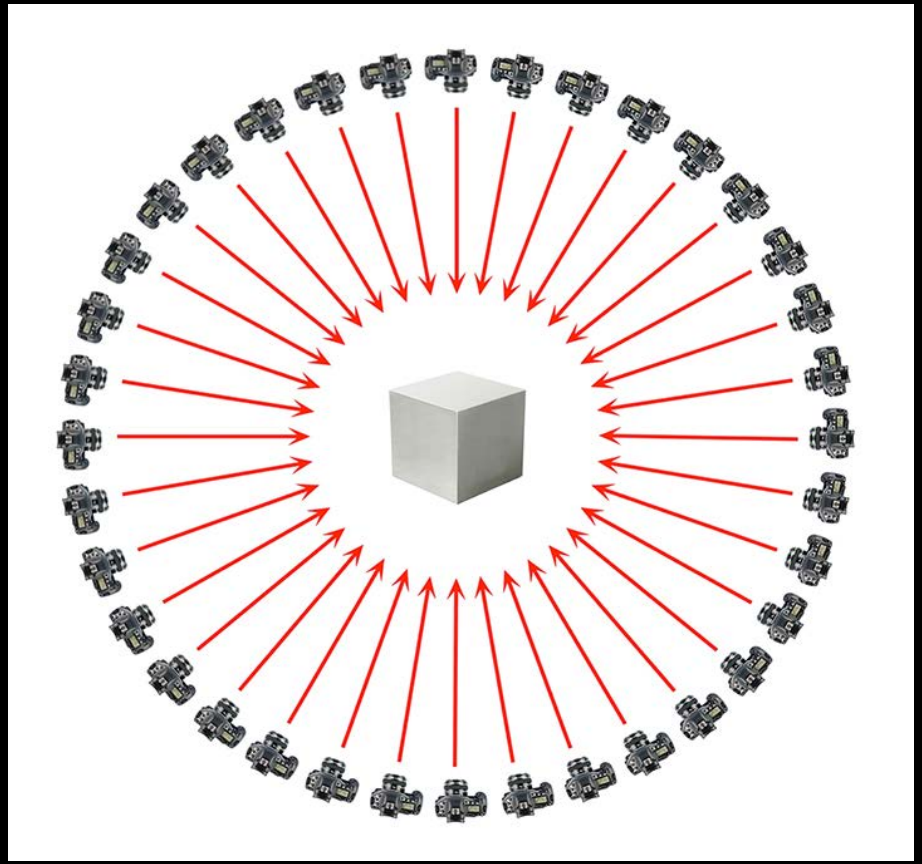


Image Preprocessing

- Converts the RAW file into a JPEG or TIFF that can be uploaded to agisoft
- ZERO OUT ALL SETTINGS
  - Want the image as the camera captures it
- Color corrections
- Lens corrections
- Save as .jpeg or .tiff AND .dng (digital negative)

Workflow

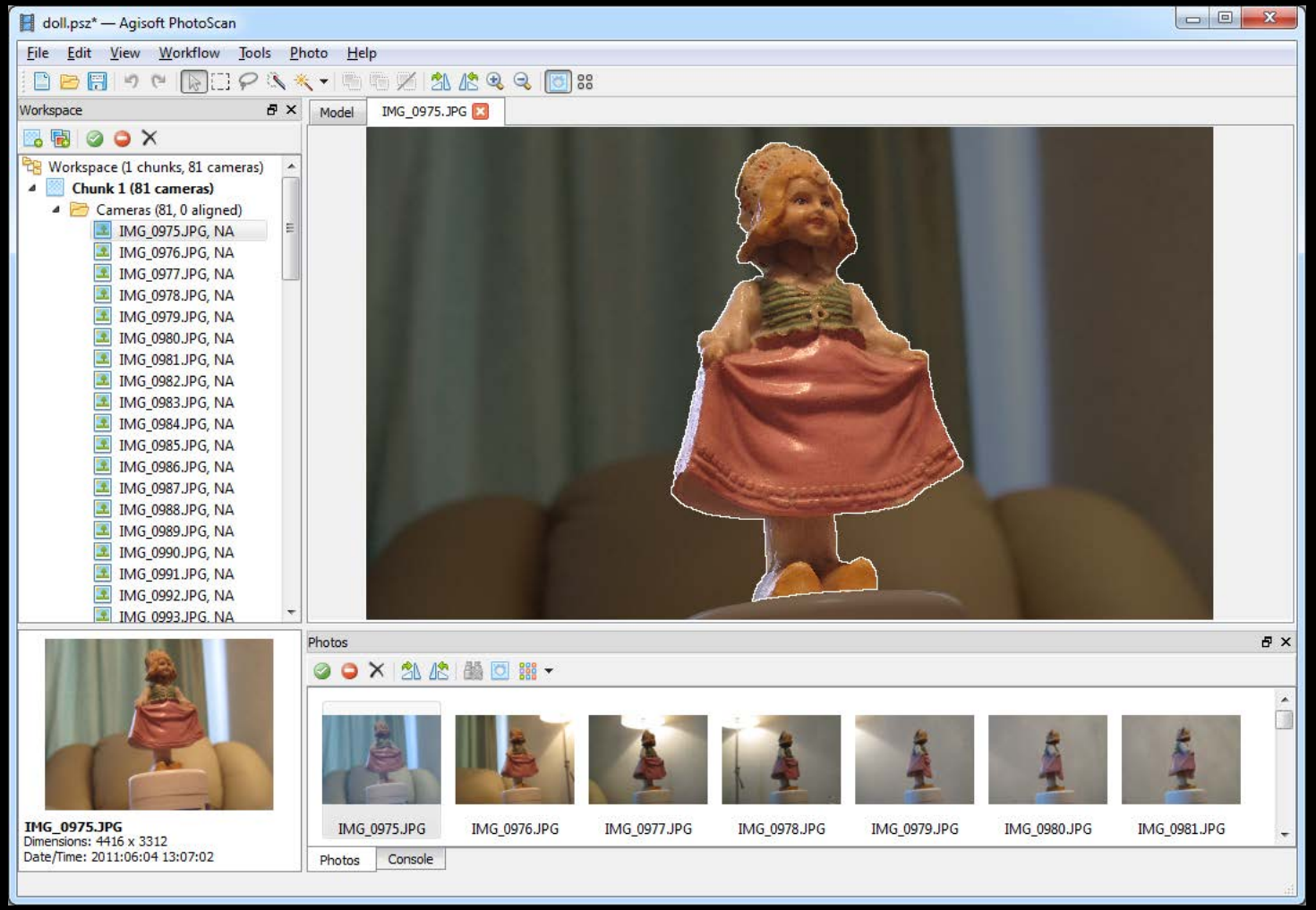
Raw Photo, No Processing

Tif after pre-processing

3D Modeling

- Agisoft Professional
- Workflow: upload photos → create masks (if necessary) → align photos → optimize sparse cloud → create scale bars → build dense cloud → build mesh → build model

Making the Mask

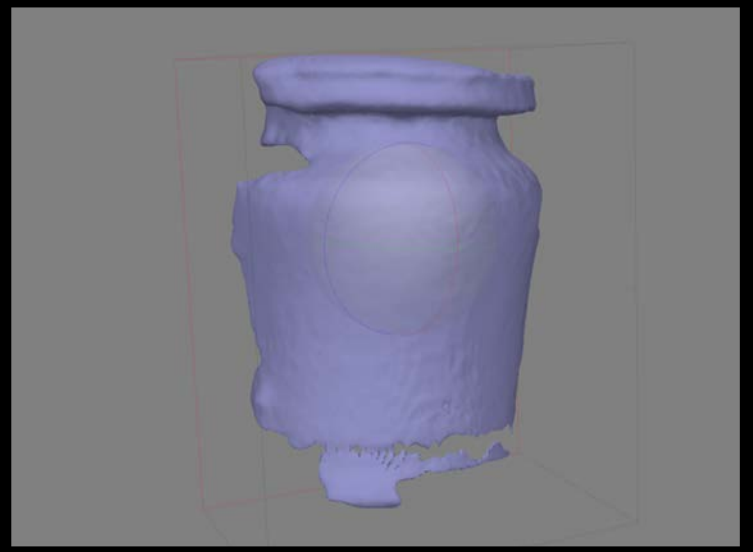


Good Optimization: Agisoft Workflow

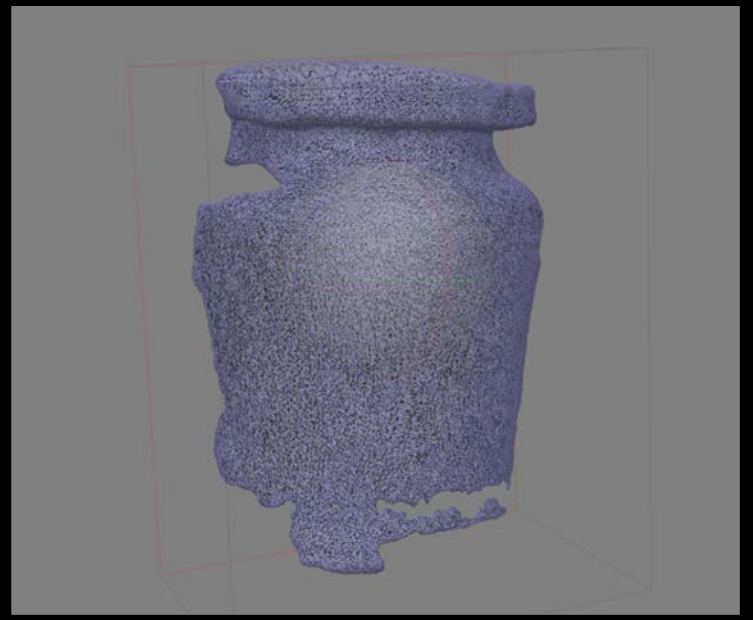
- Reconstruction Uncertainty: potential for error inherent in geometric relationship between all cameras that capture a given point.
- Projection Accuracy: potential for error based on size of the pixel neighborhood of an Interesting Point (IP).
- Reprojection error: the number, in pixel units, that indicates how well the matched points from the IPs of two or more photos actually do match.

Workflow

Dense Cloud



Solid Mesh



Wireframe Mesh

Textured and Tiled Model

Output

- 3D PDF
- Sketchfab
- https://sketchfab.com/BMCexhibition/models

Useful Links

Google Doc for BMC Special Collections

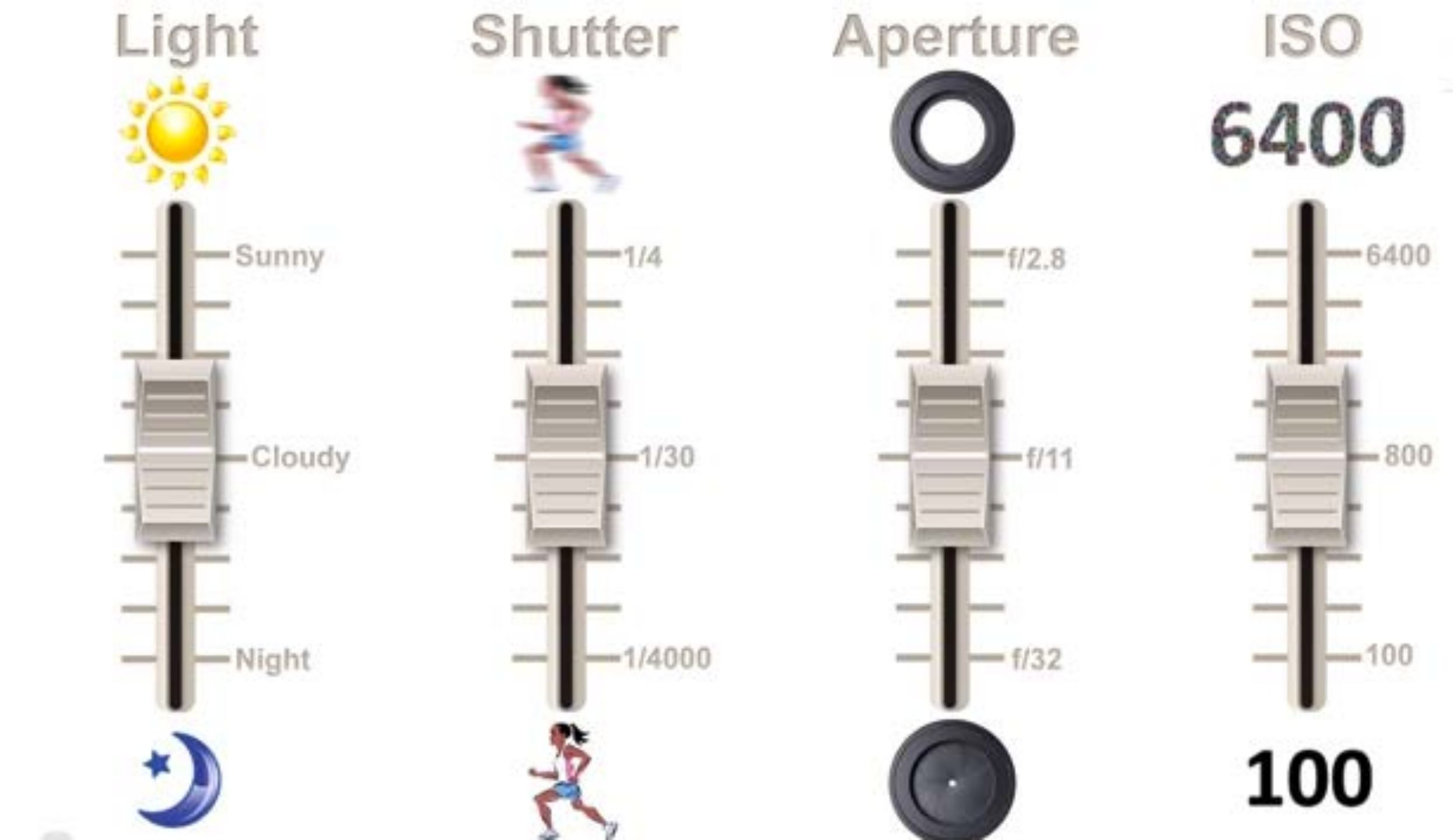
CHI Photogrammetry Website
http://culturalheritageimaging.org/Technologies/Photogrammetry/

CHI Videos
https://vimeo.com/channels/practicalphotogrammetry


F1,4
F2
F2,8
F4
F5,6
F8
F11
F16
F22
F32


1/1000
1/500
1/250
1/125
1/60
1/30
1/15
1/8
1/4
1/2


ISO 50
ISO 100
ISO 200
ISO 400
ISO 800
ISO 1600
ISO 3200
ISO 6400
ISO 12800
ISO 25600


Light
Sunny
Cloudy
Night
Shutter
1/4
1/30
1/4000
Aperture
f/2.8
f/11
f/32
ISO
6400
6400
800
100
100

Lets more light in ← Aperture Range → Lets less light in

f/2.8

f/4

f/5.6

f/8

f/11

f/16

Large Aperture ← Medium Aperture → Small Aperture

Shallow DOF ← Depth of Field → Greatest DOF