Using Close-Range Photogrammetry to Analyze Paleontological Excavations

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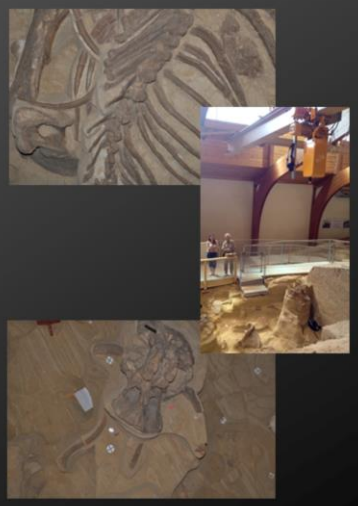
Traditional Field Methods

The Mammoth Site of Hot Springs, SD Inc.

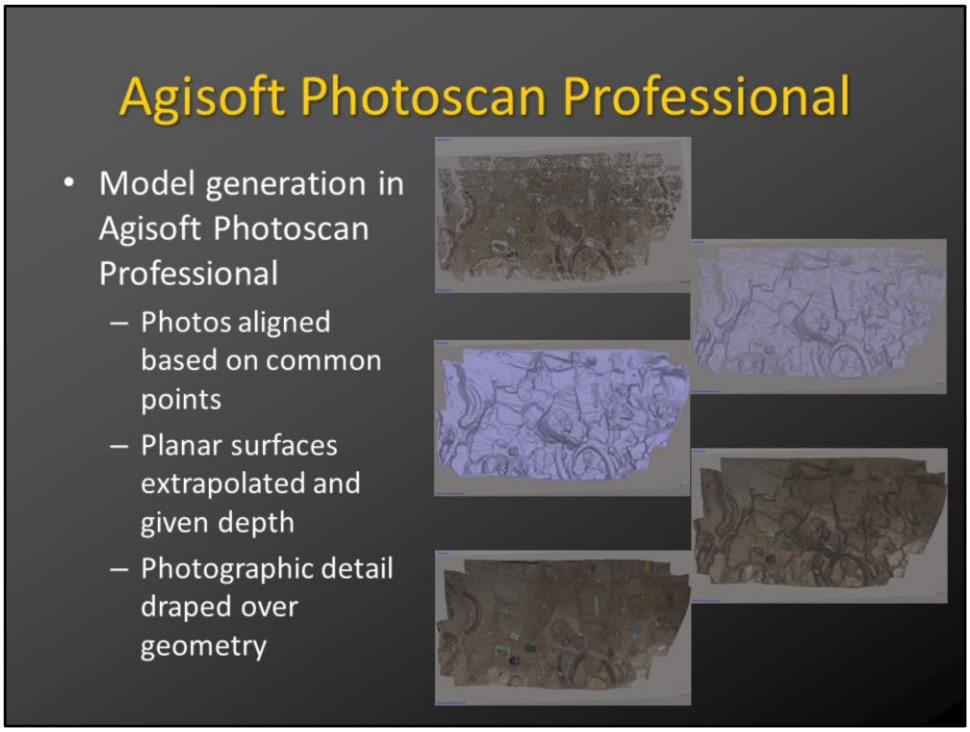
- An abundance of fossil material exposed and in place
  - 61 mammoths, both Columbian (*Mammuthus columbi*) and Woolly (*Mammuthus primigenius)*
  - 81 other vertebrate, invertebrate, and microvertebrate species
- Multiple skulls and skeletons, in various orientations, to test measuring techniques and document specimen orientations

The Mammoth Site of Hot Springs, SD Inc.

- Data collected with:
  - Nikon D5100 dSLR camera
  - Fixed 35mm lens
  - 16.2 MP
- Over 10,000 photographs acquired
  - 3 main areas documented on a weekly basis, 4,550 ft^2 area (423 m^2)
  - 750 ft^2 area (70 m^2) documented daily for 1 week
- HP Z420 Workstation
  - Intel Xeon E5-1620, 3.7 GHz
  - Quad Core Hyper-threaded processor
  - nVidia Quadro K2000
  - 32 GB DDR3 1600 MHz RAM



F mount, AOV 1.5 x lens focal length, 23.6 x 15.6 mm CMOS sensor, 16.9 total pixels, JPEG size: 4.3 MB. TIFF 96.5 MB: ; RAW size: 21 MB.

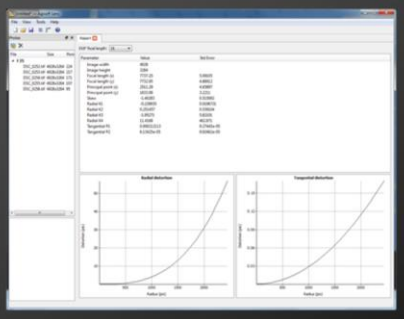


Can build a sparse point cloud or a dense point cloud – has potential to have more data points than a laser scanner.
Planar surfaces extrapolated in 3 separate steps – 1. Wire frame made across surfaces, 2. Wire frame given depth, 3. Surfaces smoothed to create geometry.

Streamlined GUI interface with very little user control

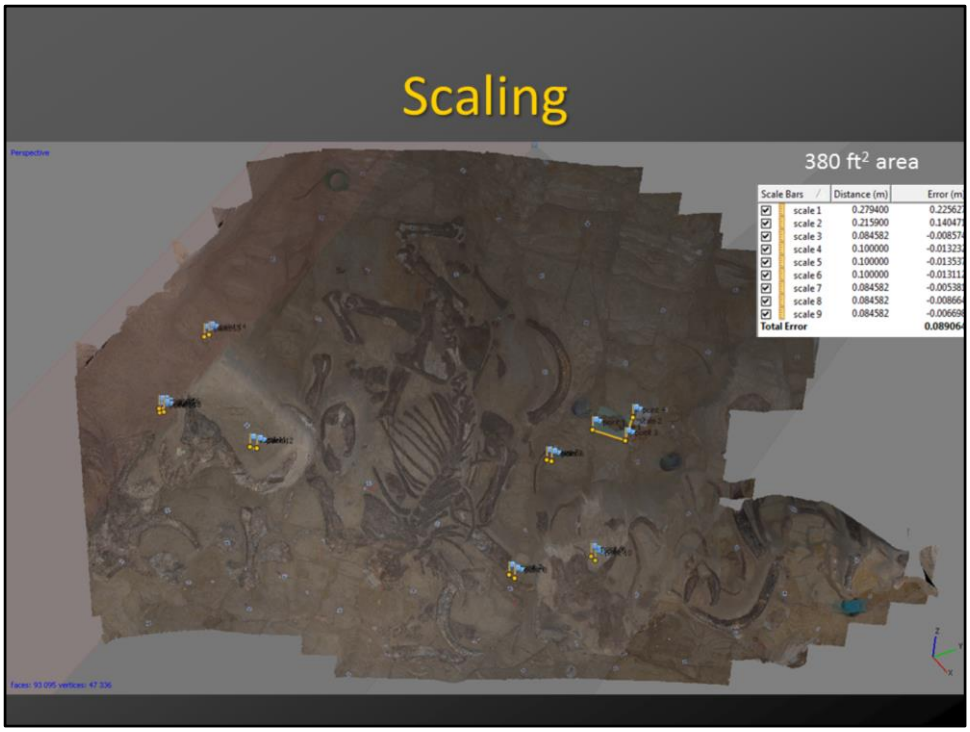
Agisoft Photoscan Professional

- Can calibrate camera lens with Agisoft Lens
  - Agisoft Photoscan also "automatically calibrates" lens during model generation



Autocalibration feature works fairly well – no noticeable difference in models build with the autocalibrate verses ones built with lab calibrated lens.

Final portion of the Mammoth Site refer to as the Upper Bed.
Rotatable on all 3 axes, can zoom in or out.



Can scale models one of two ways:

- Use GPS coordinates- either with GPS receiver on the camera or by importing at least 3 GPS coordinates for placed markers
- Create scale manually by building scale bars based on known lengths within the study area or actual scale bars. After creating scale bars, can then "Optimize" model to apply scale across scene. Results from the optimization are shown in the "View Estimated Scale Bar" window, like the box in upper right corner. It indicates the error associated with each measurement and total error across the scene.

Murray, 380 square feet, 8.9 cm error

Scaling


Perspective
Scale Bars
Distance est
Error (m)
scale 1
0.096093
-0.003907
scale 2
0.086488
0.001829
scale 3
0.086706
0.002048
scale 4
0.084312
-0.000346
Total Error
0.002394
Faces: 84 542 vertices: 42 810

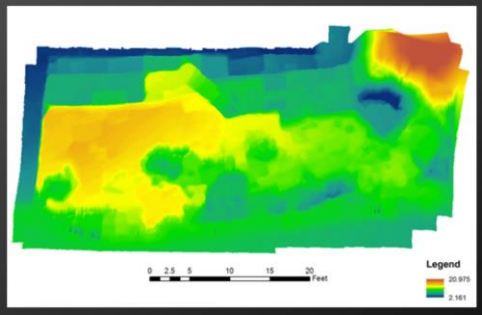
Camera was farther away so the model has less detail when zoomed in and more error across the model area. Also issues with shadows and there is the need for oblique photos of the area to aid in texture generation for side areas (like the walls).

Preliminary Results

- Generated model statistics:
  - Bone measurement errors accurate between 0.346 mm and 50 cm
  - Ground resolution 0.000374347 m/pixel
  - Point density 1,0440.7 points per m^2
- Can document bone positions in greater detail and in the same amount of time than with the string grid system

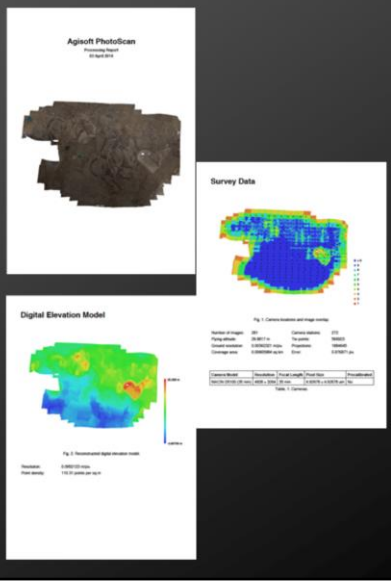
Output Formats

- Can export in lots of formats:
  - Adobe PDF
    - Rotatable image
  - Google Earth KMZ
  - XYZ point cloud
  - ASPRS LAS file
  - Orthophotos
    - JPEG, GeoTIFF, PNG
    - Huge amount of detail
  - Arc/Info ASCII Grid
    - DEM generation



Output Formats

- Can export in lots of formats:
  - Agisoft Photoscan Professional Generated Report
    - Camera height
    - Photo overlap
    - Ground resolution
    - Pixel size
    - Elevation change in DEM



Future Work

- Comparison of data collected from CRP models to that traditionally collected
  - Statistical analysis of measurements made by hand and from models
  - Collect and analyze images collected at outdoor excavation
- Conduct a taphonomic study of specimens at an excavation from CRP models
  - Measuring specimen orientations from models
- Cyclical monitoring surveys with same set-up
  - Erosion monitoring
  - Possibly include UAVs in photograph acquisition
- Transfer to lab to document field jacket preparation

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