Drone Image Processing

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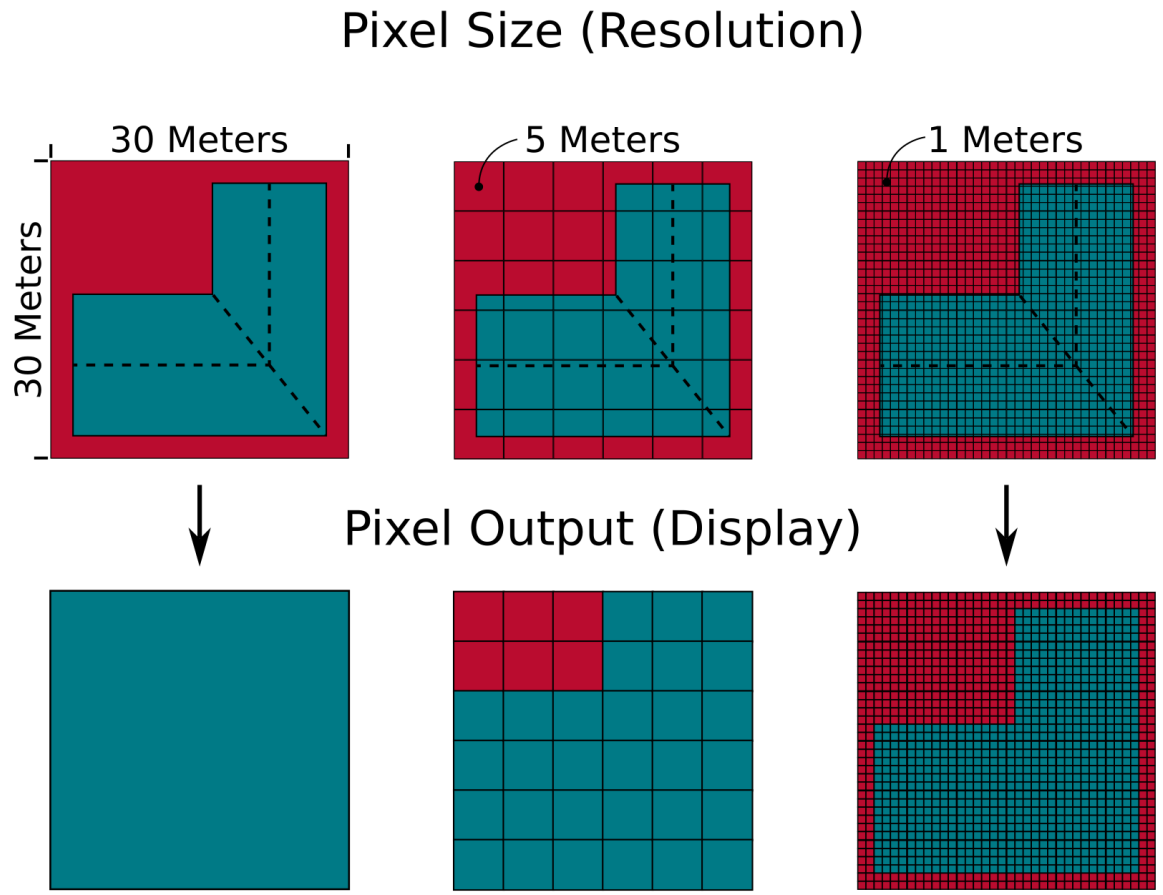
Drone Image Characteristics

- **Spatial Resolution**
  - **Sub-inch**
  - **Millimeter**
- **Temporal Resolution**
  - **Hourly**
  - **Daily**
- **Spectral Resolution**
  - **RGB (Red, Green, Blue)**
  - **NRGB (Near-infrared, Red, Green, and Blue)**
- **Radiometric Resolution**
  - **8-bit**
  - **16-bit**



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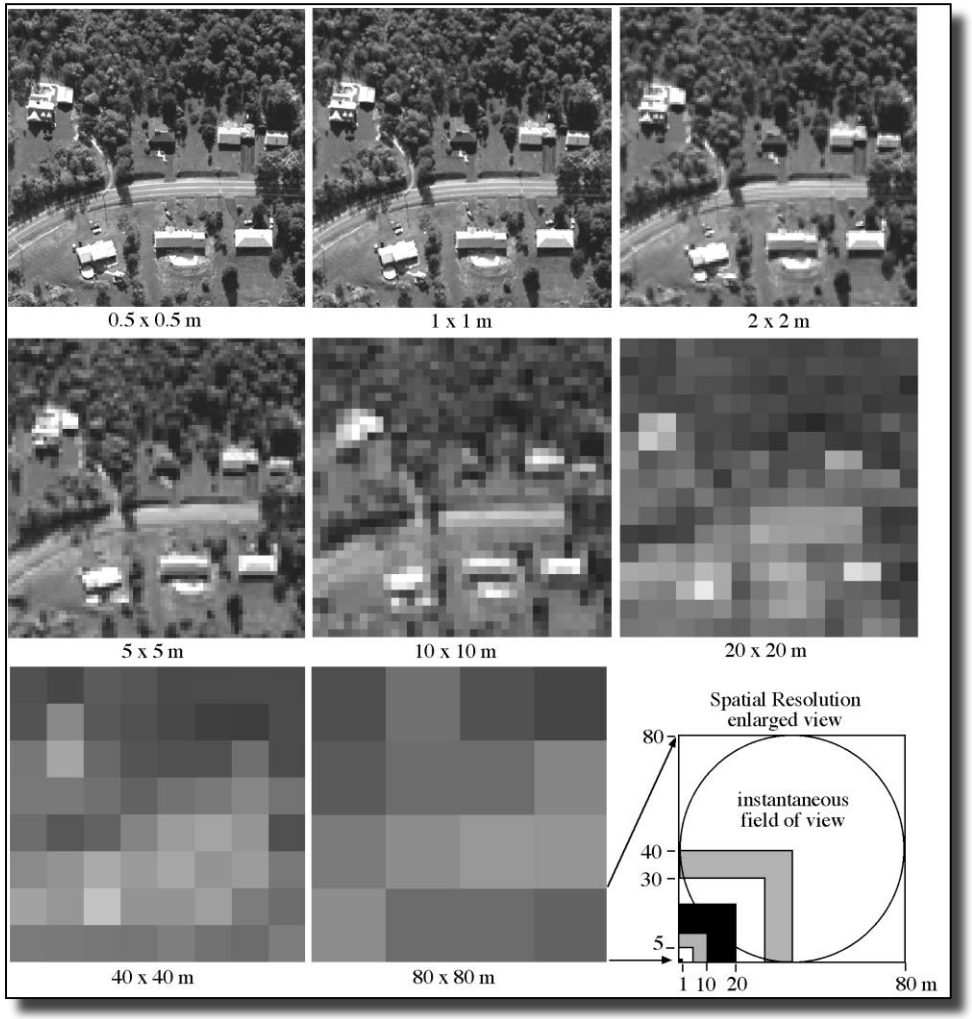

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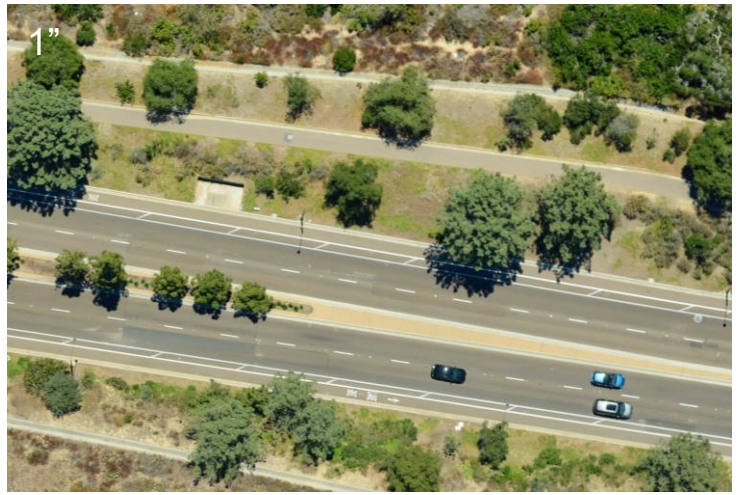

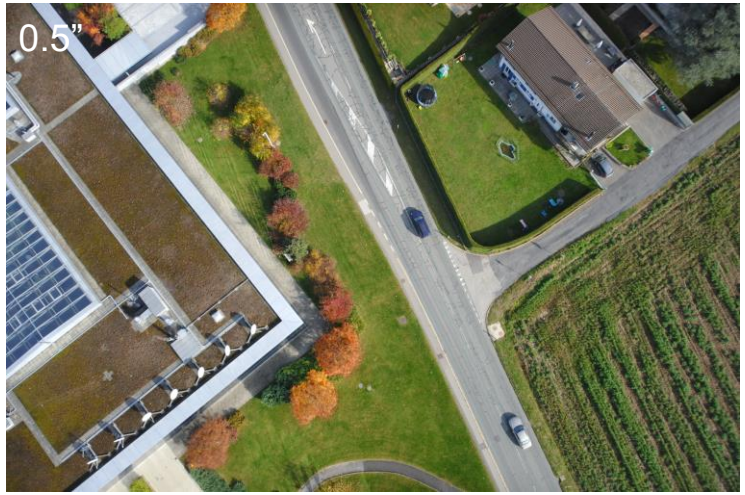

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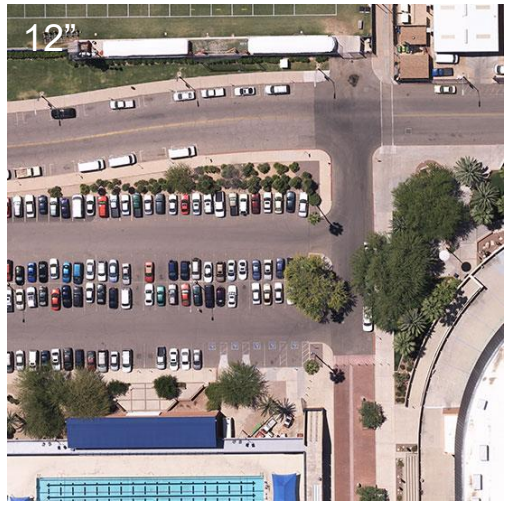

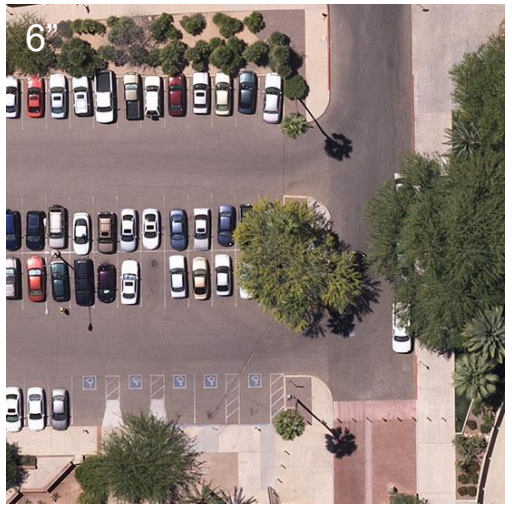

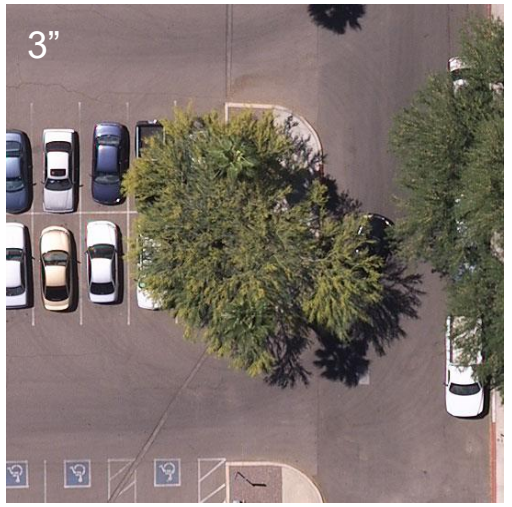

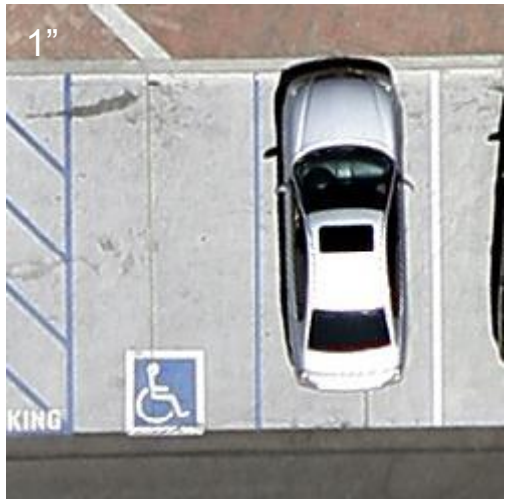

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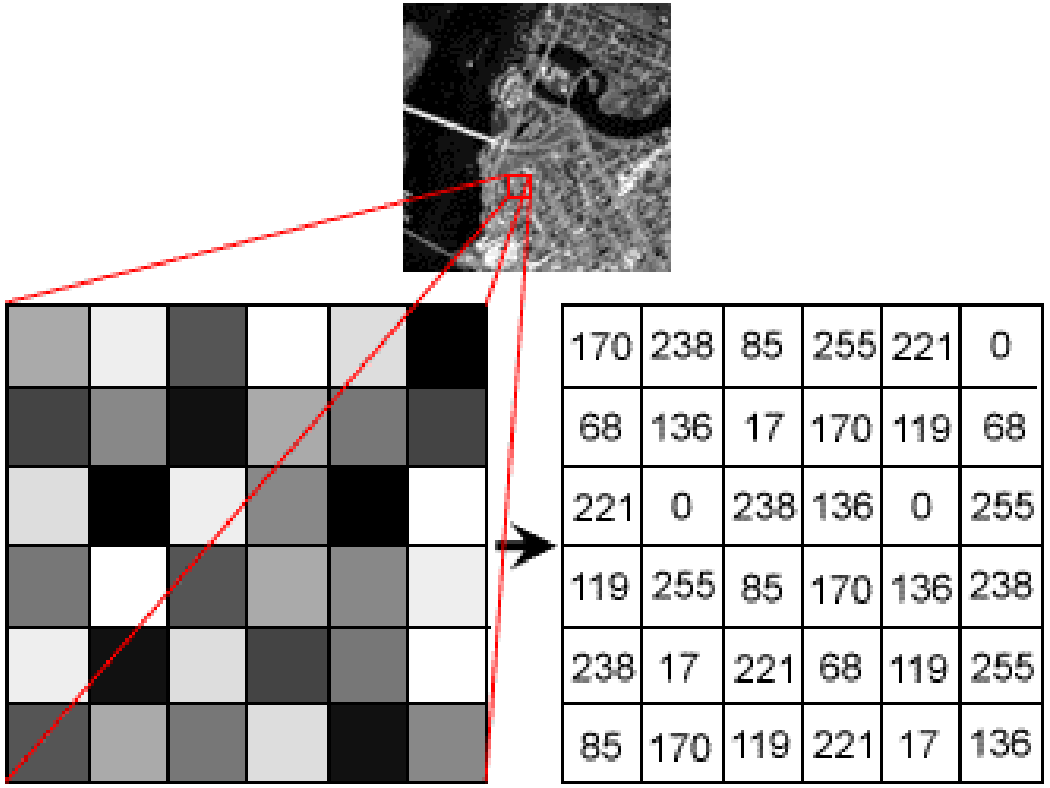

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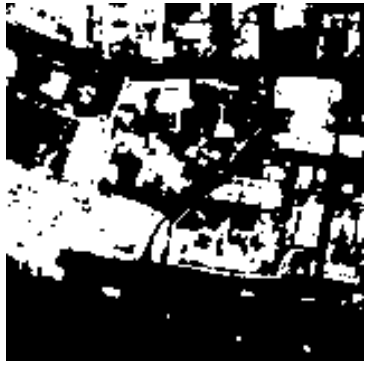
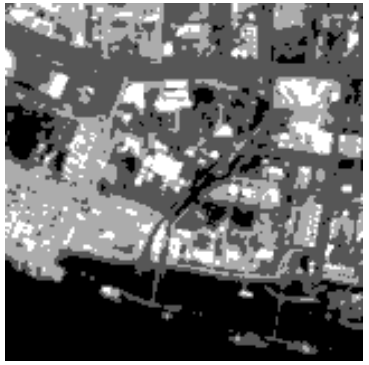


1 - bit



2 - bit

8 - bit

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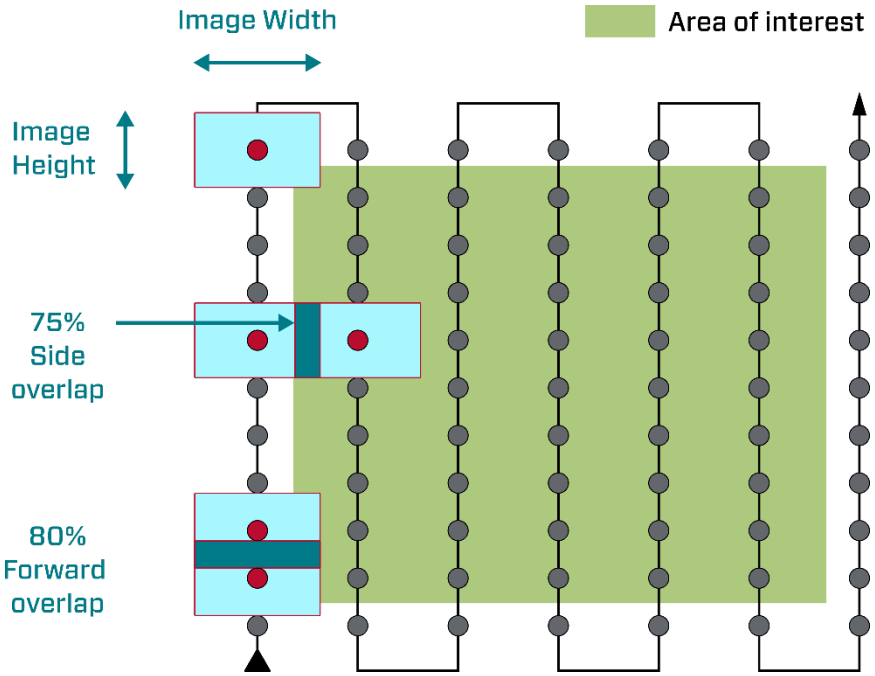
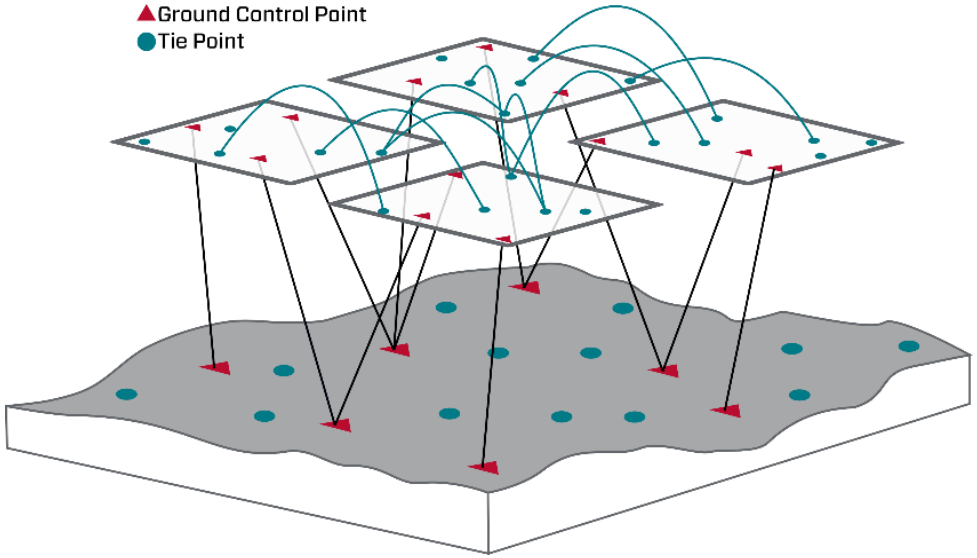
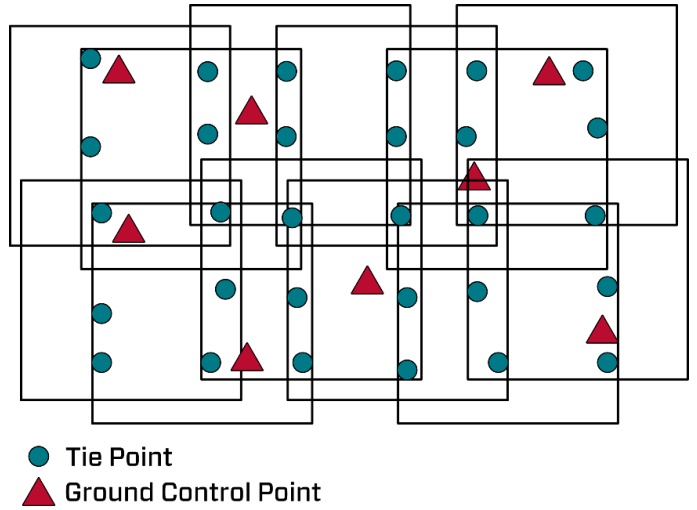
Aerial Triangulation

- Aerial Triangulation (AT)
  - Structure from Motion
  - Multiple-View Stereo (MVS)
  - Determines ground coordinates of points on the aerial photos







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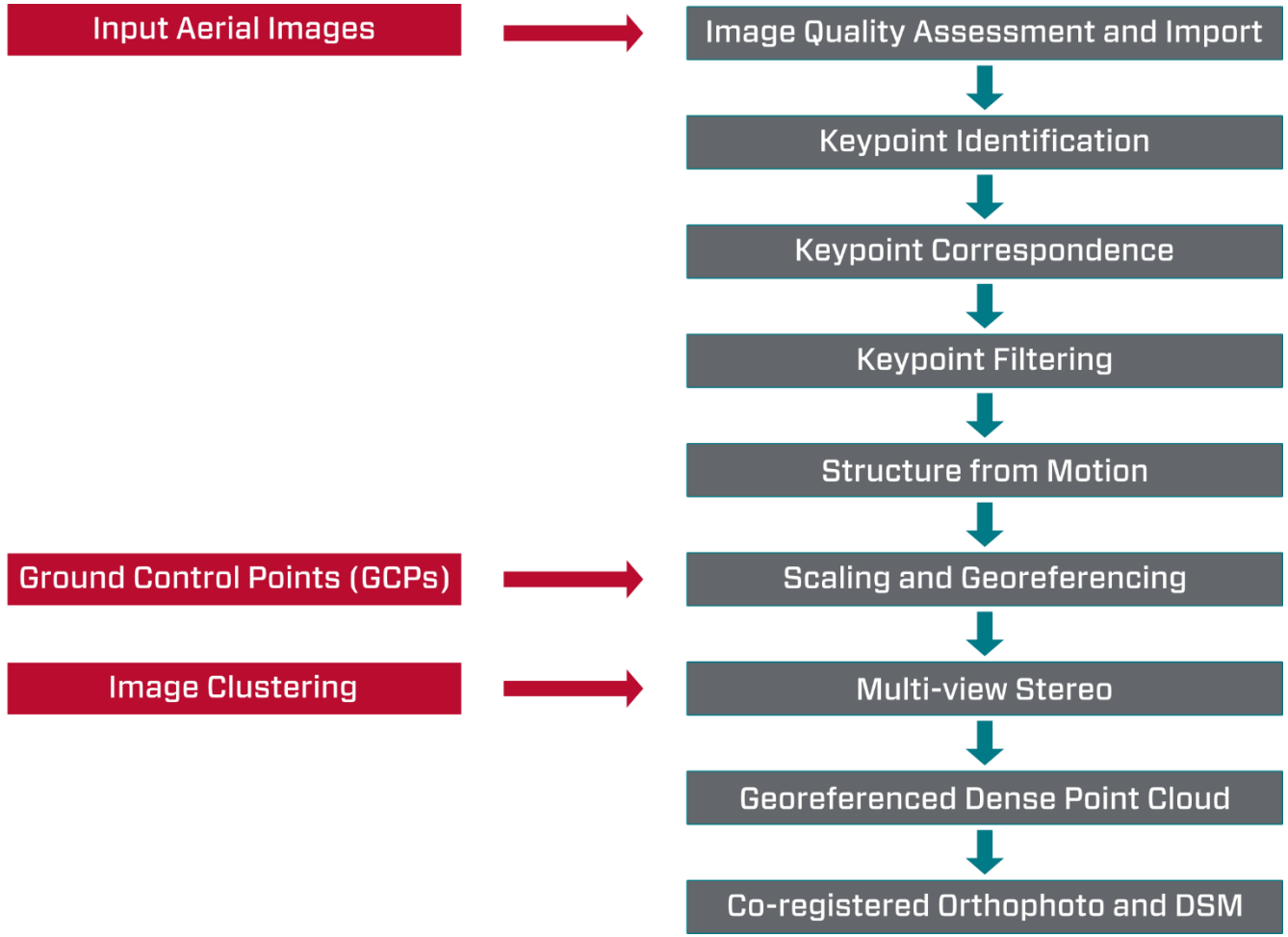
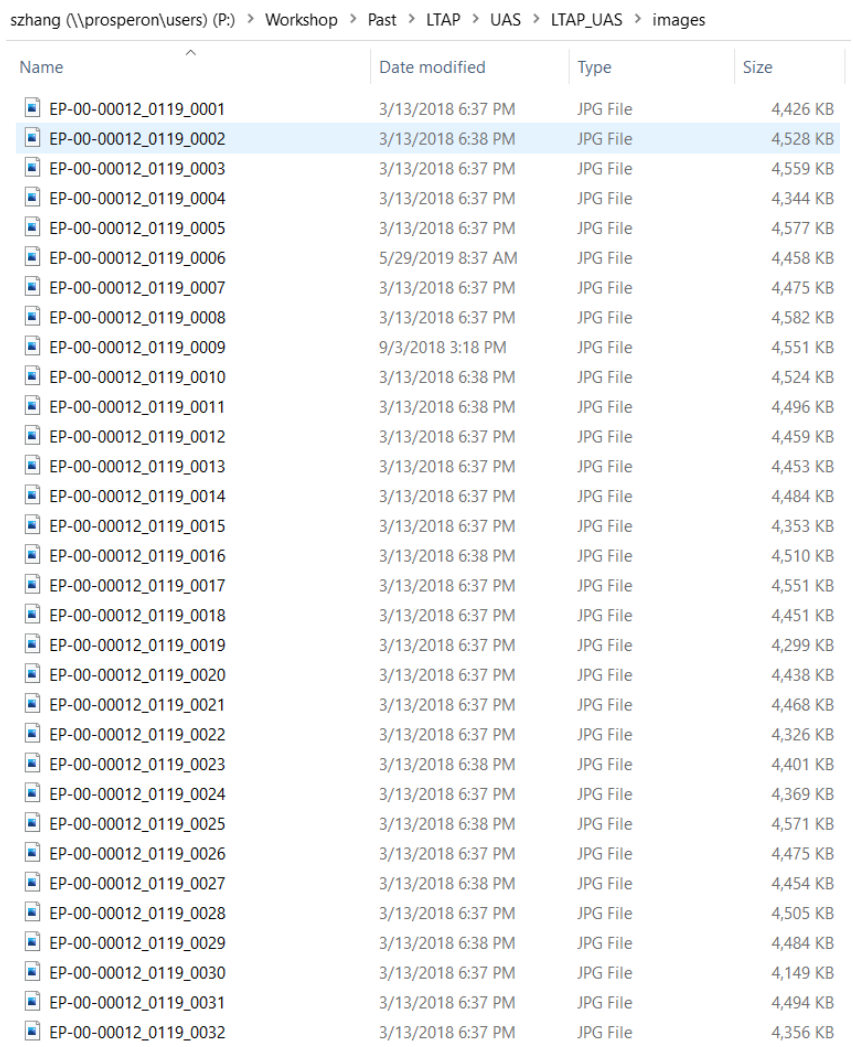


Input Aerial Images

- Collected from UAS
  - Autonomous flight
  - High-spatial resolution
  - Copy from Micro SD Card to local storage drive



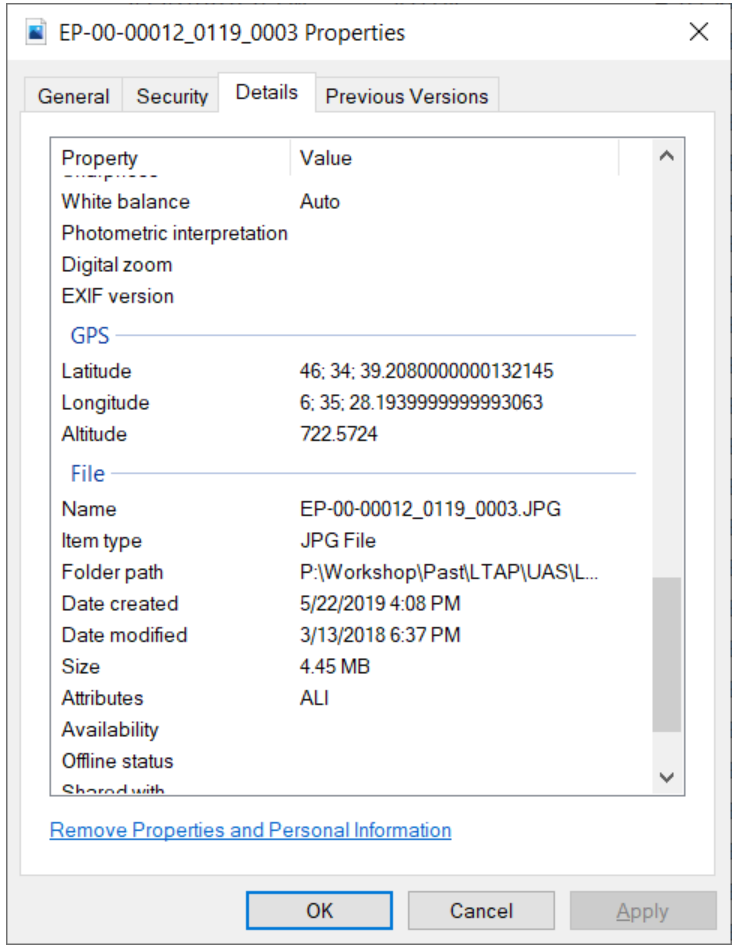
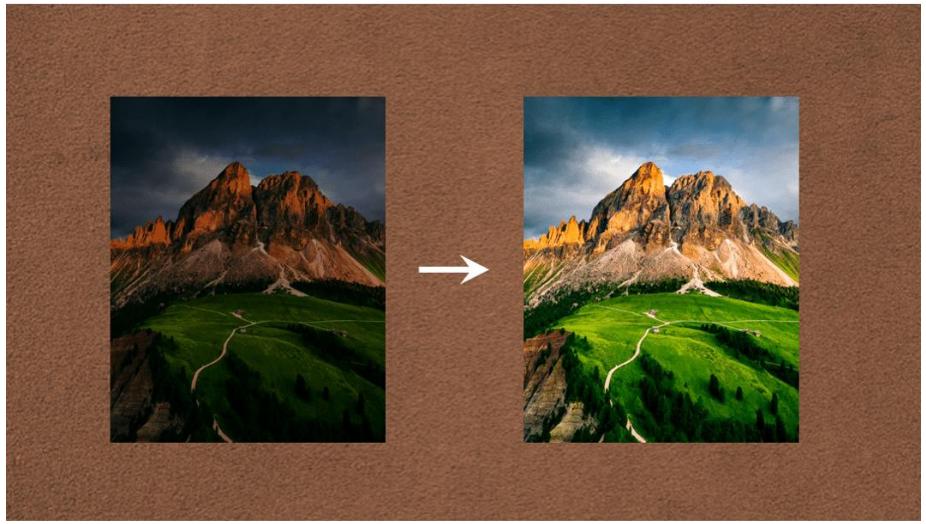


Image Quality Assessment and Import

- Quality Assessment
  - Brightness
  - Contrast
  - Sharpness
  - Coordinate
- Import
  - Load images to image processing software
  - Load all images at once
  - Load images in chunks



Keypoint Identification

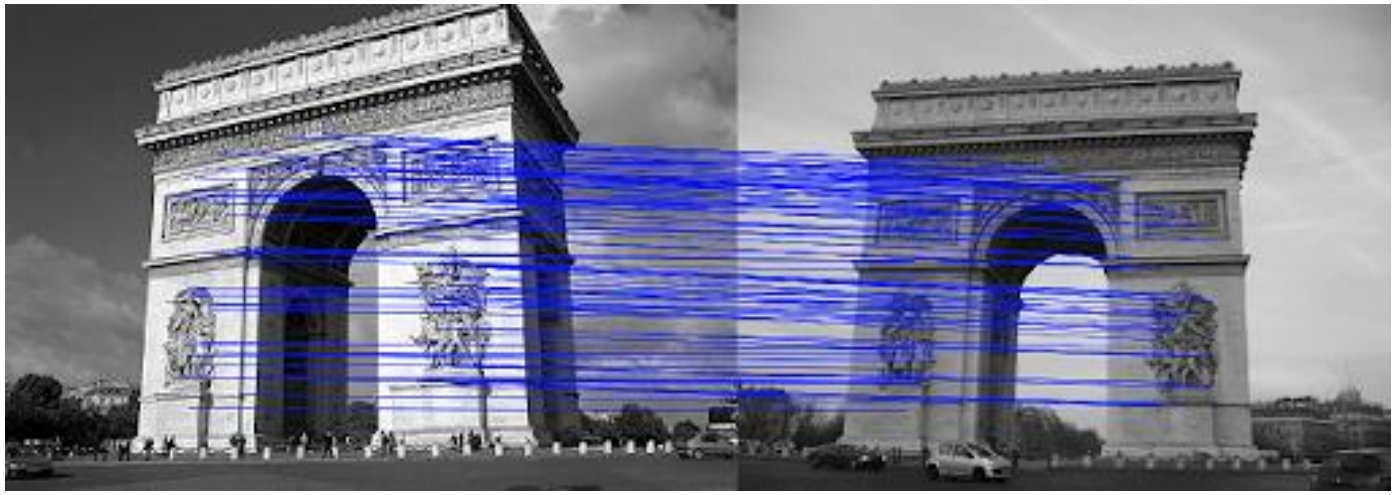
- Keypoints
  - Also known as tie points
  - Features that can be clearly identified on an image
  - Have different 3D position, scale, and orientation

- Keypoints Identification
  - Enables image matching and scene reconstruction
  - Many algorithms exist, but the most common one is scale-invariant feature transform (SIFT)

Keypoint Correspondence

- Keypoint Correspondence
  - Essentially correspondence lines
  - Needs to be determined and established

- Noting
  - There is no assurance that any given keypoint in an image will have a matching keypoint in another image
  - Keypoint correspondence involves discarding keypoints that do not have a matching partner

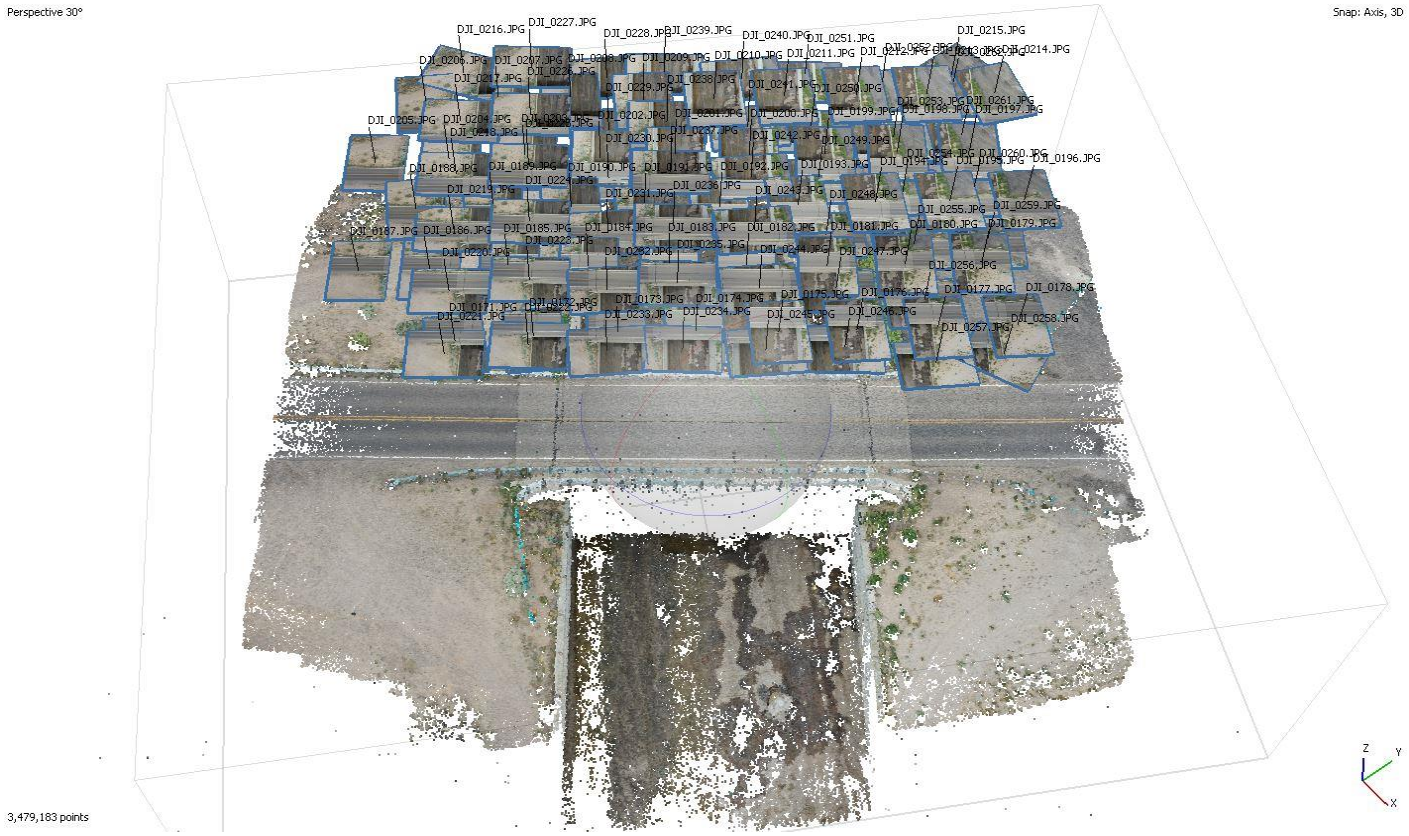


Keypoint Filtering

- Further Processing
  - Keypoint correspondence to filter out any erroneous matches
  - Many methods are available, but one of the most robust and accurate one is Random Sample Consensus (RANSAC)

Structure from Motion

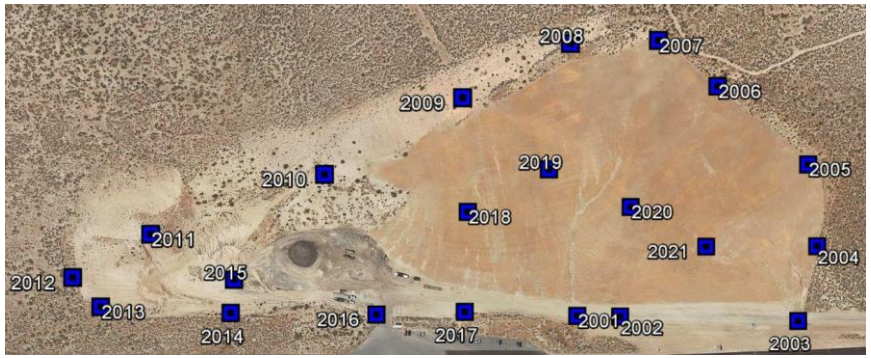
- SfM
  - Focuses on estimating camera poses and then reconstructing the 3D geometry of a scene
  - Intrinsic parameters
  - Extrinsic parameters
  - Bundle block adjustment
  - Sparse point cloud



Scaling and Georeferencing

- Accurate Dimensions of 3D Geometry
  - Previous steps only estimates camera locations and scene geometry
  - Absolutely distances between cameras and reconstructed 3D points cannot be resolved from aerial images

- Scaling and Georeferencing
  - A set of Ground Control Points (GCPs)
  - Collected by survey-grade GPS equipment such as RTK



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Markers	Longitude	Latitude	Altitude (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
point 1	-106.599462	35.204256	1513.585000	0.005000	0.198197	36	0.953
point 2	-106.599424	35.204270	1513.600000	0.005000	0.170981	38	0.572
point 3	-106.599384	35.204337	1513.629000	0.005000	0.137583	43	0.590
point 4	-106.599271	35.204423	1513.607000	0.005000	0.115457	29	0.361
point 5	-106.599255	35.204388	1513.853000	0.005000	0.113435	29	0.550
point 6	-106.599411	35.204239	1513.724000	0.005000	0.114228	31	0.712
point 7	-106.599290	35.204441	1513.570000	0.005000	0.182897	34	0.867
point 8	-106.599361	35.204361	1513.618000	0.005000	0.157935	42	0.540
point 9	-106.599458	35.204303	1513.567000	0.005000	0.162073	40	0.673
point 10	-106.599488	35.204254	1513.586000	0.005000	0.121016	34	0.512
Total Error							
Control points					0.150333		0.656

Scale Bars	Distance (m)	Accuracy (m)	Error (m)
Total Error			
Control scale ...			
Check scale b...			

Multi-View Stereo

- MVS
  - Uses SfM estimated camera calibration parameters to create depth maps which are used to reconstruct dense 3D geometry
  - Many methods exist, but generally can be classified into four groups, including Voxel-based methods, surface evolution-based methods, depth map merging methods, and patch-based methods
  - Dense point cloud

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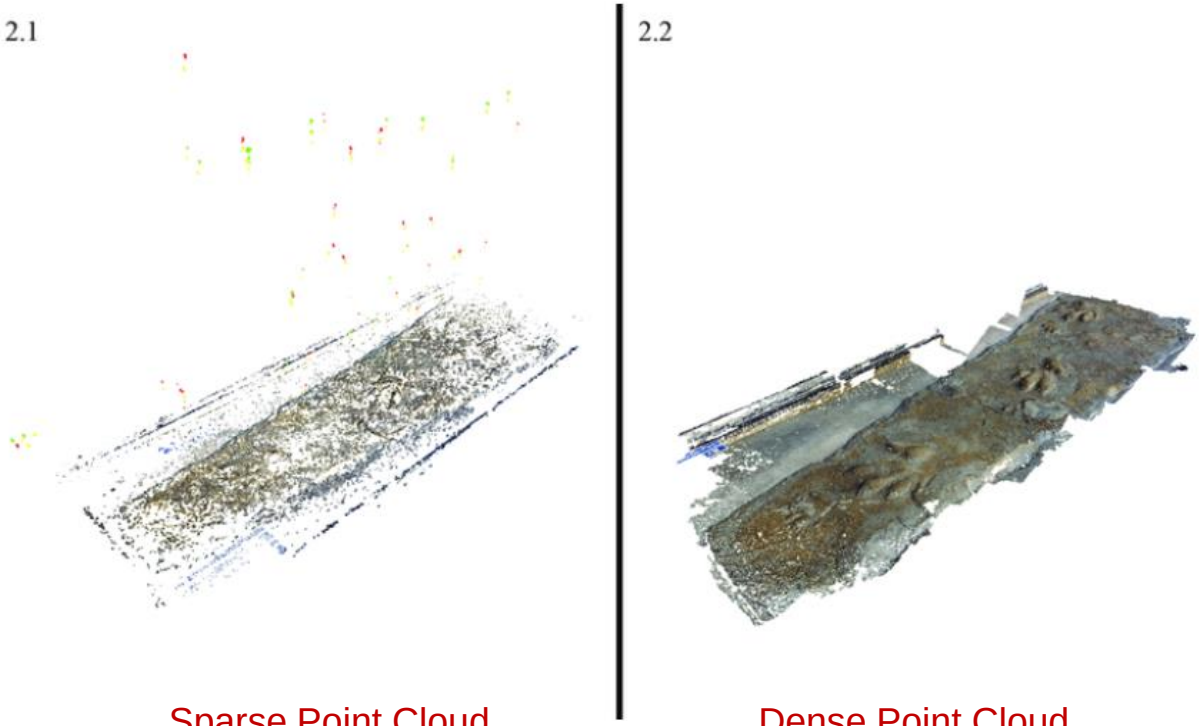
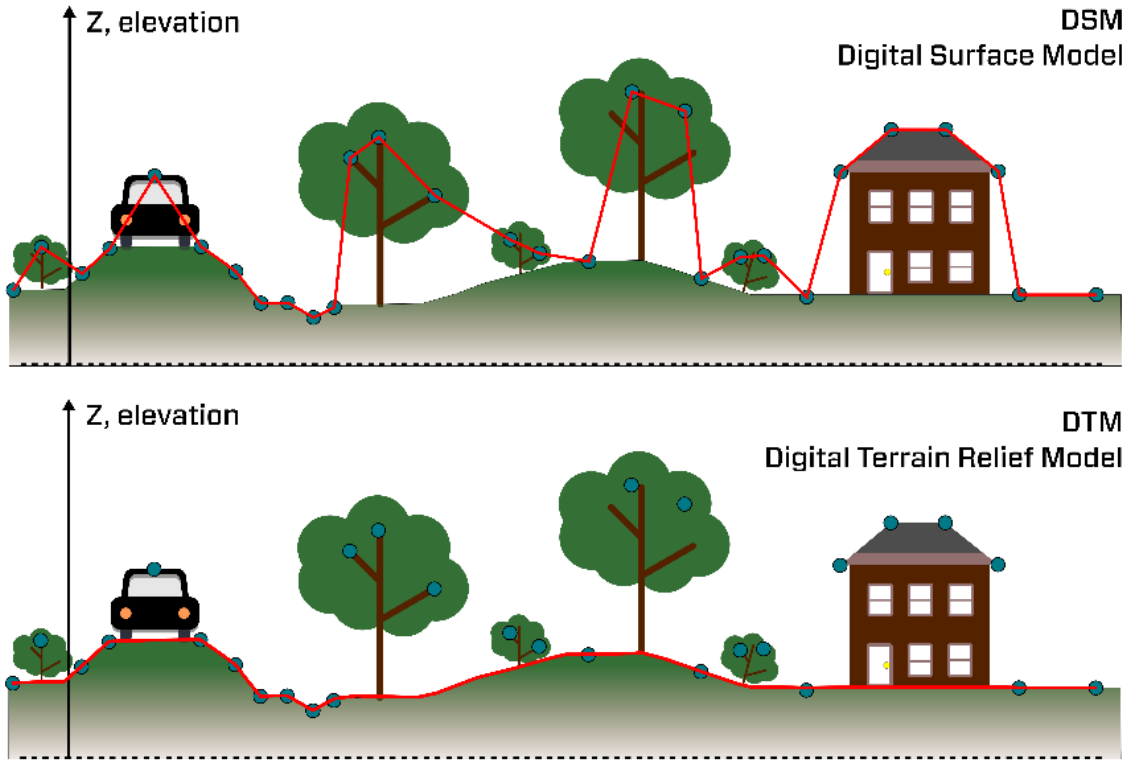


Sparse Point Cloud

Dense Point Cloud

Co-Registered Outputs

- Co-registered Ouputs
  - Orthophotos
  - Digital Surface Models (DSMs)



Orthophoto DSM

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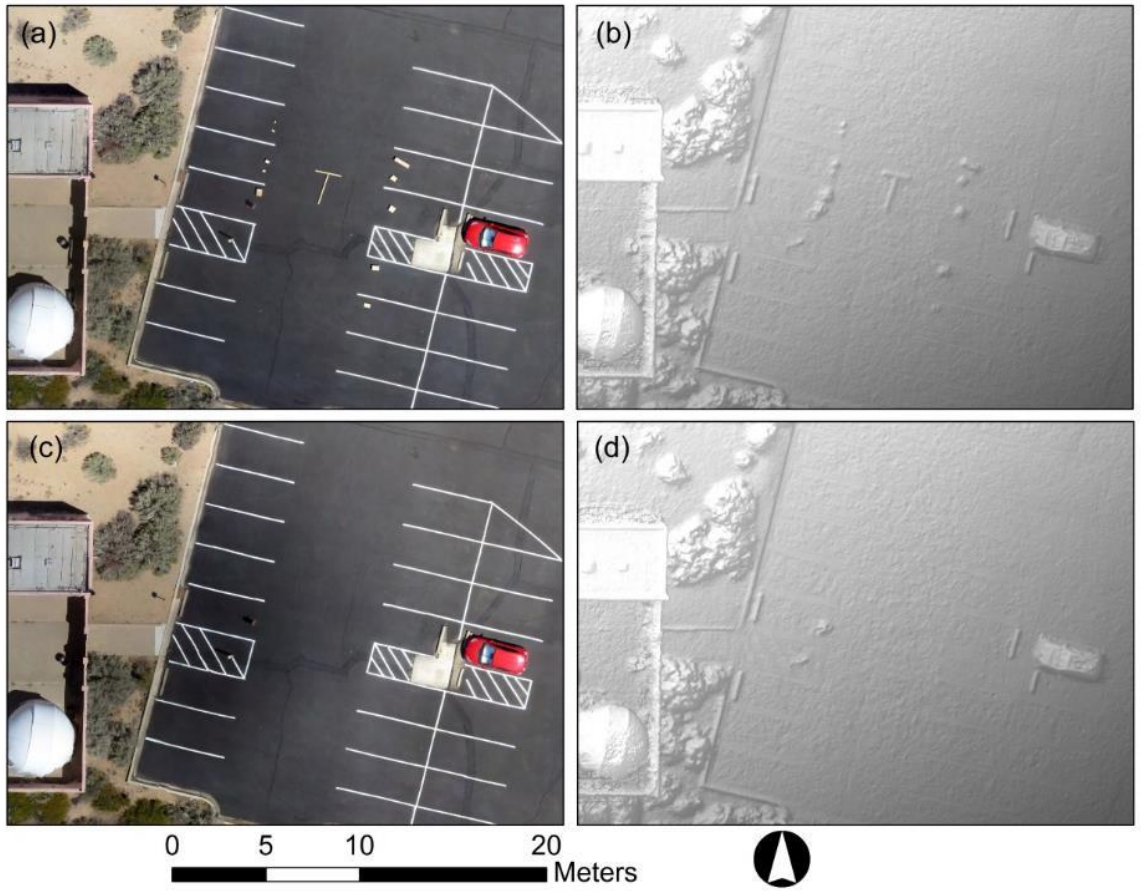


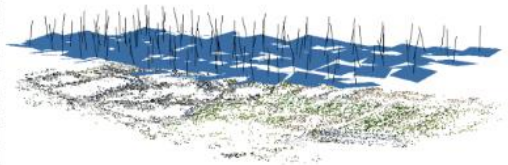
Orthophoto

DSM

Simplified Process

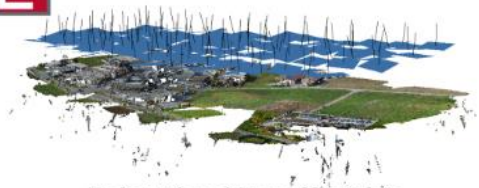
Input Images

1



Keypoint Extraction, Triangulation, Bundle Adjustment & Sparse Point Cloud Generation

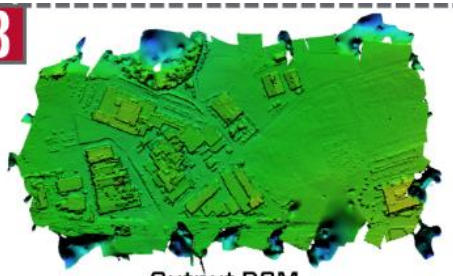
2



Point Cloud Densification

Output Point Cloud

3

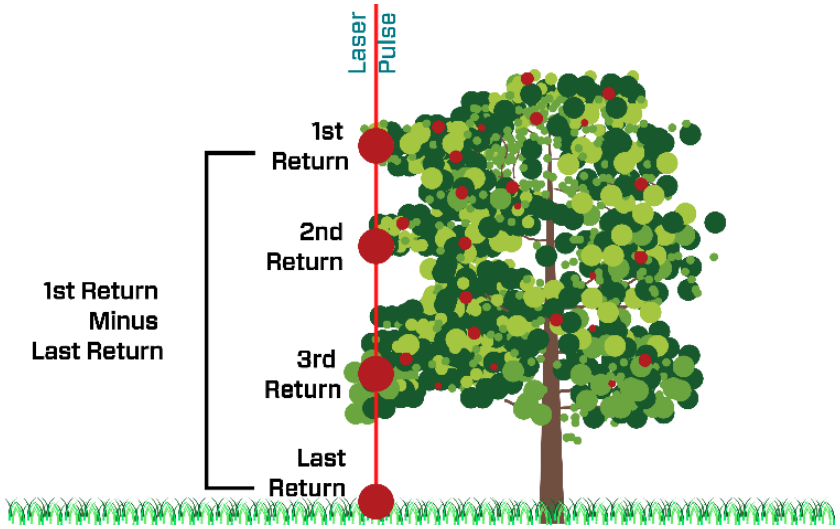


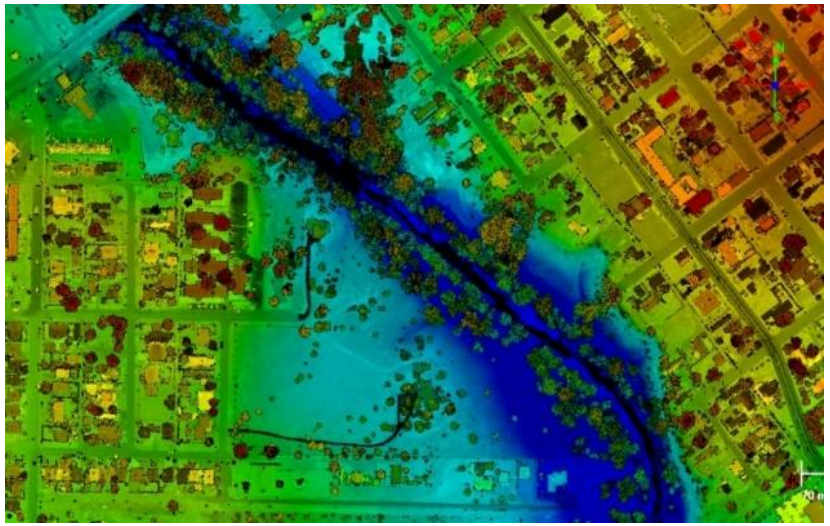
Output DSM

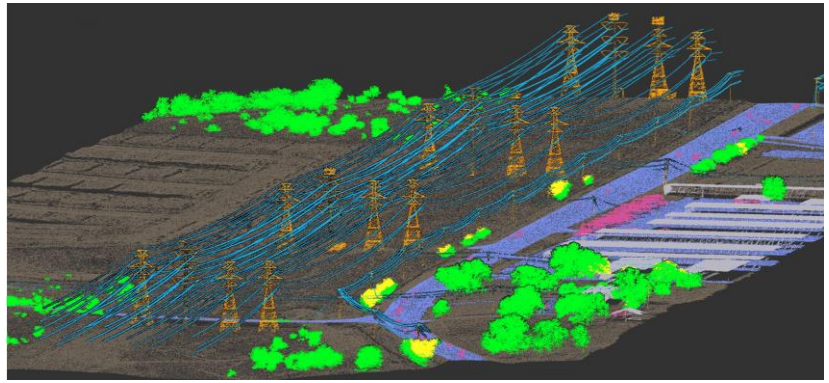
Output Orthomosaic

Airborne LiDAR

- **Airborne LiDAR**
  - **Uses light in the form of a pulsed laser to measure distance**
  - **Accurate elevation data**







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- **S-UAS Laboratory**
  - **Spatial informatics research and education**
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    - **Applications**
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    - **Aerial imagery collection**
    - **Data analytics**
    - **Aerial and ground survey**

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S-UAS Laboratory

- **Image processing and visualization**

Image Processing Benchmark

- **Benchmark**