Structure-from Motion Digital Surface Model Derived from Legacy Aerial Photography, Drum Mountains Fault Scarps, Millard County, Utah

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Summary:

Structure-from-Motion digital surface model (DSM) produced by photogrammetry using legacy single-frame aerial photographs using AgiSoft Metashape. DSM is geo-registered to the Utah AGRC 5-m auto-correlated DEM product (https://gis.utah.gov/data/elevation-and-terrain/). Nominal resolution is 0.7 m.

Personnel and Site Information:

DSM produced by Nathan Niemi, with assistance from Michael Bunds and Timothy Stahl. Because the photographic data sources for this DSM were derived from the USGS archive of scanned legacy aerial photographs (see details below), there is no site specific information associated with this project.

Products:

A point cloud (.laz format) was produced from Structure from Motion photogrammetry in July, 2020 from legacy aerial photographs collected by the USGS and USAF. The point cloud was manually registered to the Utah AGRC 5m DEM, which has coordinate specifications of NAD83 UTM zone 12N (EPSG:26912) and NAVD88 (Geoid03). Resolution is nominally 73.6 cm/pixel.

No external measurements of horizontal or vertical accuracy were determined from this legacy-derived product.

Narrative of DSM Production:

(The narrative of DSM production and table of source imagery is re-produced, verbatim, from Stahl et al., 2021, Application of legacy aerial photographs to characterize diffuse deformation in the Drum Mountains fault zone, Basin and Range province, Utah, USA, Frontiers in Earth Science v. 8, 600729, doi:10.3389/feart.2020.600729. See that manuscript for detailed discussion of comparison of this DSM to the Utah AGRC 5-m autocorrelated DEM derived from 1-m NAIP aerial photography and a cm-resolution DSM derived from terrestrial lidar scanning, relevant to applications in neotectonics and surface processes.)

We created a DSM of the Drum Mountains from legacy single frame aerial photographs collected by multiple government agencies archived at EarthExplorer (http://earthexplorer.usgs.gov). Single frame aerial images were selected from three flight projects (Table 1) flown in the 1970s by the United States Geological Survey (USGS) and the United States Air Force (USAF). Nominal scales of the aerial images were between 1:20,000 and

1:34,000. Stereo overlap for each of the three flight projects was 60%. The images are all monochrome or infrared single band images. Camera calibration files were available for the USGS flight projects, and included camera and lens information, as well as calibrated lens focal lengths; however, this information was not available for the USAF flight project. No other camera calibration or aircraft orientation data were available for the images. Film negatives from the USGS flight projects were scanned at approximately 1,000 dpi resolution and corrected for scan distortions. Film negatives from the USAF flight project were scanned at approximately 400 dpi resolution and not corrected for distortions introduced by scanning.

Table 1:

Flight project	Scale	Flying height (ft)	Year flown	Agency	Stereo overlap (%)	Frames used	Camera type	Lens type	Focal length (mm)	Scanned resolution (dpi)
SWDW0	20,500	6,000	1970	USGS	60	67	Wild Heerbrugg RC9	Wild Super Aviogon	88.57	1,000
VCMW0	34,000	17,000	1970	USGS	60	88	Zeiss RMK A 15/23	Zeiss Pleogon A	152.45	1,000
CSRF0	25,000	12,553	1979	USAF	60	83	n/a	n/a	n/a	400

Aerial image files were cropped in Adobe Photoshop to remove the negative frame and to standardize image sizes for each flight project. Final images used for DSM construction were c. 8k x 8k pixels for the USGS photographs and c. 2.5k x 2.5k pixels for the USAF photographs. These images were imported into Agisoft Metashape and grouped by flight project into separate Camera Groups. Each Camera Group was assigned the appropriate lens focal length, if known, and all other camera calibration parameters (i.e., interior and exterior orientations) were determined by optimization within the software. Images were aligned in Agisoft Metashape without the use of external tie points on an Intel 6-core i7 CPU with 32 GB of RAM, supplemented by a Tesla K40 GPU. From the aligned images, a dense point cloud was generated using an aggressive depth filtering technique. The resultant point cloud covered c. 800 km^2 at a ground resolution of 73.6 cm/pixel. Typical image overlap across the Drum Mountains fault zone was >9 images, and nowhere less than 5 images.

The dense point cloud was georeferenced by identifying matching points on both the legacy aerial imagery and recent (2018) 60-cm color aerial orthophotographs produced by the USDA NAIP program. Coordinates of the matching points were extracted from the Utah 5-m autocorrelated DEM in the NAD83 UTM zone 12N (EPSG:26912) coordinate system using ArcGIS Pro. The X, Y, and Z coordinates of the tie points were then manually entered into Agisoft Metashape. The georeferenced point cloud was exported from Agisoft Metashape in .las format.