Structure from Motion (SfM) survey – southern Banning strand of the San Andreas Fault and Landers earthquake scarp on the Emerson Fault

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1. System Description and Specifications

This survey was performed with an 11 mm Nikon D5100 camera from a tethered helium balloon platform. Full details of the two surveys can be found in K. Johnson et al., “Rapid mapping of ultra-fine fault zone topography with Structure from Motion”, submitted to Geosphere, 2014.

2. Areas of Interest

The survey area consisted of two small regions along faults in southern California. Both datasets were produced in order to test the accuracy and feasibility of our Structure from Motion (SfM) system. (1) The Washington Street site is located ~20 km due east of Palm Springs and covers a short section of the southern Banning strand of the San Andreas Fault that cuts through an alluvial fan and has not ruptured historically. This site serves as a test site for paleoseismic studies. (2) The Galway Lake Road site is ~45 km north of Yucca Valley. This site covers a segment of the Emerson Fault ruptured by the 1992 Mw 7.3 Landers earthquake and tests the feasibility of SfM as part of the immediate scientific response following an earthquake.
Figure 1 – Location of the Washington Street (top) and Galway Lake Road (bottom) sites (Google Earth).
3. Data Collection

a) **Survey Date:** The Washington Street photographs were collected on 02/02/2013, and the GCPs were collected independently by Kate Scharer on 01/03/2013. The Galway Lake Road photographs were collected on October 26, 2012.

b) **Ground GPS**

Nine ground control points were used for each site.

For the Washington Street site, a GeoXH was used to record GPS data along features such as ridgelines, bars, and swales. These data were overlain on a GoogleEarth image, which was easily correlated with the orthophoto produced using Structure from Motion. Nine features (rocks, bushes, stream/path intersections) identifiable in both images were used as ground control points.

For the Galway Lake Road site, GCPs were derived from TLS data collected independently in 2009 (see Haddad et al., 2012).

4. Data Deliverables

a) **Horizontal Datum:** WGS 84/ UTM, Zone 11

b) **Vertical Datum:** HAE (ellipsoid)

c) **Projection:** WGS84/NUTM11

d) **File Formats:** Along with the formats below, raw data (the photographs used in processing) are also available.

   Washington Street site:
   - 1. 3 cm DEM in TIFF format
   - 2. point cloud (90% >700 points/m² with 50% >60 points/m²) in LAS format

   Galway Lake Road site:
   - 1. 2 cm DEM in TIFF format
   - 2. point cloud (90% >530 points/m² with 50% >65 points/m²) in LAS format

5. Processing Report
Survey Data

Number of images: 233
Flying altitude: 73.8689 m
Ground resolution: 0.0259524 m/pix
Coverage area: 0.066803 sq km

Camera stations: 233
Tie-points: 262799
Projections: 1378568
Error: 0.810445 pix

<table>
<thead>
<tr>
<th>Camera Model</th>
<th>Resolution</th>
<th>Focal Length</th>
<th>Pixel Size</th>
<th>Precalibrated</th>
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<tbody>
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<td>NIKON D5100 (11 mm)</td>
<td>4928 x 3264</td>
<td>11 mm</td>
<td>5.03235 x 5.03235 um</td>
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Table. 1. Cameras.
Ground Control Points

Fig. 2. GCP locations.

<table>
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<tr>
<th>Label</th>
<th>X error (m)</th>
<th>Y error (m)</th>
<th>Z error (m)</th>
<th>Error (m)</th>
<th>Projections</th>
<th>Error (pix)</th>
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<td>0.202555</td>
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<td>point 3</td>
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<td>0.133488</td>
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</table>

Table. 2. Control points.
Digital Elevation Model

Fig. 3. Reconstructed digital elevation model.

Resolution: 0.0259524 m/pix
Point density: 1438.89 points per sq m