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JIFX After Action Report (AAR) JIFX Experiment Number (X-00): B-11

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JIFX/RELIEF Experiment Number (*X-00*):

B-11

Experiment Title:

Rapid, High Spatial Resolution Image Assessment of Post-Earthquake Damage

Organization:

San Diego State University Center for Earth Systems Analysis Research (CESAR), TerraPan Labs LLC., and NEOS Ltd. This experiment is part of the Naval Postgraduate School (NPS) - Remote Sensing Center (RSC) Earthquake Response Exercise.

Experiment Lead/Point of Contact:

The experiment lead is Professor Douglas A. Stow, Dept. of Geography, San Diego State University. Fred Kruse is the Naval Postgraduate School point of contact.

Quantitative Results:

Our experiment integrated with several other NPS RSC earthquake response exercises and demonstrated rapid and automated change detection with airborne imagery as part of a post-earthquake disaster response scenario. Airborne imagery captured by a digital color camera mounted on a NEOS Ltd. light sport aircraft platform and resultant change detection products were transferred in electronic form and integrated into the RSC earthquake response system. A single flight line was delineated across the axis of the cantonments area of Camp Roberts and a swath covered by three overlapping images was imaged multiple times on both August 15th and 16th (Figure 1). Each day, the aircraft flew a single flight line six times collecting 3 inch spatial resolution imagery, and three times collecting 6 inch spatial resolution digital color imagery. Three images were collected on each imaging pass, with 100 m spacing between them along the flight line. After the completion of each imaging pass by the aircraft, participants on the ground at the cantonments site moved several targets to simulate changes, including boxes, tarps, canopies, and strips of strapping and duct tape.

When imaging was complete each morning, the aircraft landed at Paso Robles airport and the digital images and supporting metadata files were delivered to the McMillan Airfield by ground vehicle. Upon arrival at the RELIEF event, the images and associated information about aircraft position and heading at the time of image acquisition were input into an automated work flow which included automated image co-registration (using an algorithm developed and coded from scratch by SDSU/TerraPan participants) and automated change detection (also developed by SDSU/TerraPan participants).

Figure 1. Flight line used for repeat-pass imaging of the cantonments area and detection of moving change targets.

Of the images collected on Wednesday August 15th, 10 pairs of images were found by the automated processing routine to be within a strict 1 m Euclidean distance between imaging stations, and these images were automatically co-registered as the next step in the processing pipeline. Of these 10 pairs, three were not co-registered with sufficient accuracy to perform detailed changed detection as determined by visual inspection in the web-based visualization and analysis tool. This likely resulted from inaccuracy in the results of a student generated automated point matching routine. On the second day, 16 images were found to match within a 1 m threshold. Four of these images were co-registered poorly by the automated co-registration routine, but the remainder were visually accurate, with many seemingly within 2-3 pixel registration accuracy.

Since the same area of ground was imaged by all six passes, we focused on a pair of images for each day that were co-registered within 2 pixel accuracy, selected by quick visual inspection in the web-based viewer (Figures 2-5). On the first day, a total of eight aggregate features changed. Two of these features were not detected. A pile of white boxes, which was stacked in the first frame and knocked down in the second time frame, was not detected likely due to similarity with the bright soil background. Likewise, a person with a low profile was not detected. Some small features such as boxes and peoples shadows were only partially detected, while large changes such as the movement of a car, rotation of a canopy, and slight movement of a blue tarp were reliably detected. Three false detections occurred where shadows moved substantially were highlighted with the default parameters for the change analysis algorithm.

For the Thursday August 16th mission, 10 changes were staged between each pass, for the selected pair of images. All but two of the changes were detected. One was a person that appeared in the frame, and the second was a small teal tarp that was moved. With default parameters on the change analysis algorithm (the parameters are interactively adjustable as part of the demonstration), no false detections occurred and white boxes that were challenging to detect based on Day 1 (Wed.) imagery were well detected. A closing car trunk door was detected,

and the tarps that changed position were well quantified in terms of their shape and area in the image change product.

Qualitative Results:

The imaging and change detection demonstration was successful, and results contributed to the larger NPS coordinated earthquake response exercise. Specialized image collection and processing techniques yielded pixel-level spatial co-registration between ultra-high spatial resolution (3-inch) imagery, and the automated change detection routine detected many of the introduced change targets with little false change detection. The automated processes were made possible by server side processing that combined and optimized all automated components. Change detection products were presented in a web-based visualization tool that allowed visual interpretation of the images and change detection results, interactive adjustment of change detection parameters, and submission of change detection results (graphics and text) to the common operating picture of the NPS exercise via GeoRSS feed.

The image-based change detection results that fed into the common operating picture as a GeoRSS feed contributed to the overall situational awareness of the simulated earthquake response event. The efforts of all of the NPS exercise team members made SDSU's process from image collection to results in a common operating picture seamless.

Mr. Dave Potter with the City of Monterey Emergency Services met individually with Pete Coulter to discuss the technology. Mr. Potter was interested in the capability for rapid image-based change detection, and was very happy that current, 6-inch spatial resolution imagery serving as a baseline for future change detection would be made available to him and his colleagues. During the NPS team presentations Thursday afternoon, Mr. Potter was particularly interested in how well *ad hoc* imaging attempts could perform relative to the repeat pass imaging and facilitate rapid change analysis.

Please document, if applicable, other groups you interacted/collaborated with and what you worked on (please be as descriptive and detailed as possible):

SDSU's image-based change products were submitted to the NPS common operating picture managed by Peak Spatial Enterprises using their sensor island platform (Figure 6). The change analysis and visualization tool developed by TerraPan Labs, as part of the SDSU team, was used to highlight significant change detections. Then, the tool was used to publish entries to a GeoRSS feed on a TerraPan Labs web server. This GeoRSS feed was monitored by the sensor island software and new entries were displayed on the map in the common operating picture. GeoRSS entries contained descriptive text, change detection image chips, and were referenced to point locations on the map. As an alternative publishing source, the XML file for the GeoRSS feed was also uploaded to a virtual machine hosted on the EOC in a box that NPS managed. This allowed publishing of the GeoRSS over the satellite internet connections hosted by the EOC in a box in the case that the feed could not be updated through standard internet sources.
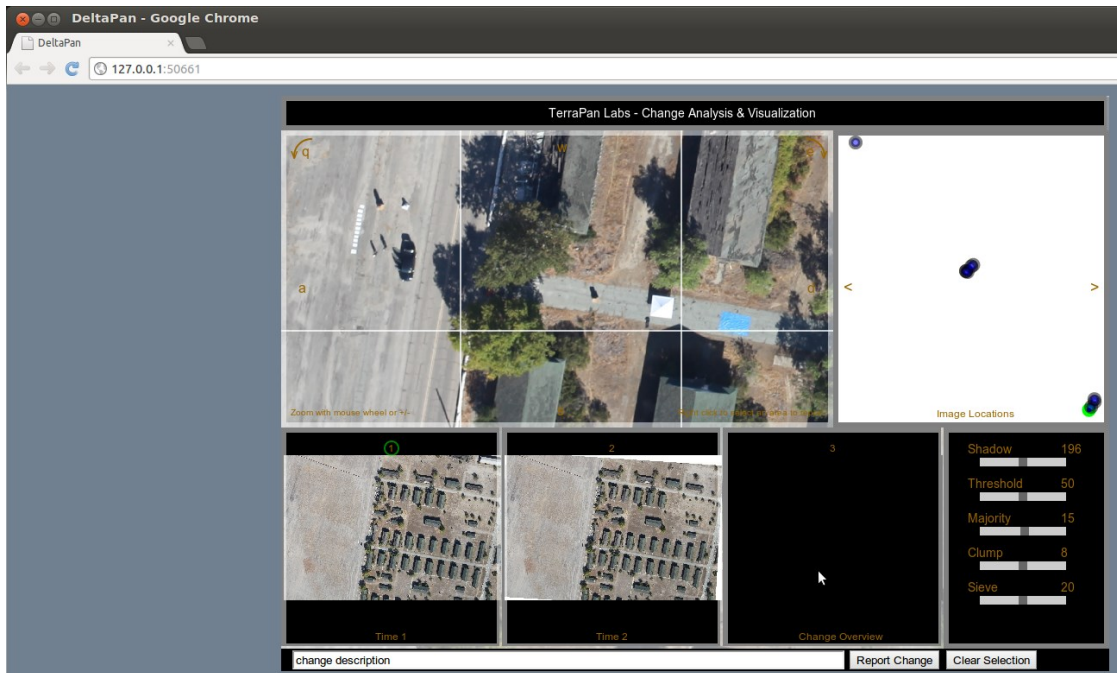
Figure 2. Review of multitemporal images in web-based change detection and visualization tool. The white box to the right shows the location of the change on a map when connected to high speed internet, but was turned off at RELIEF.
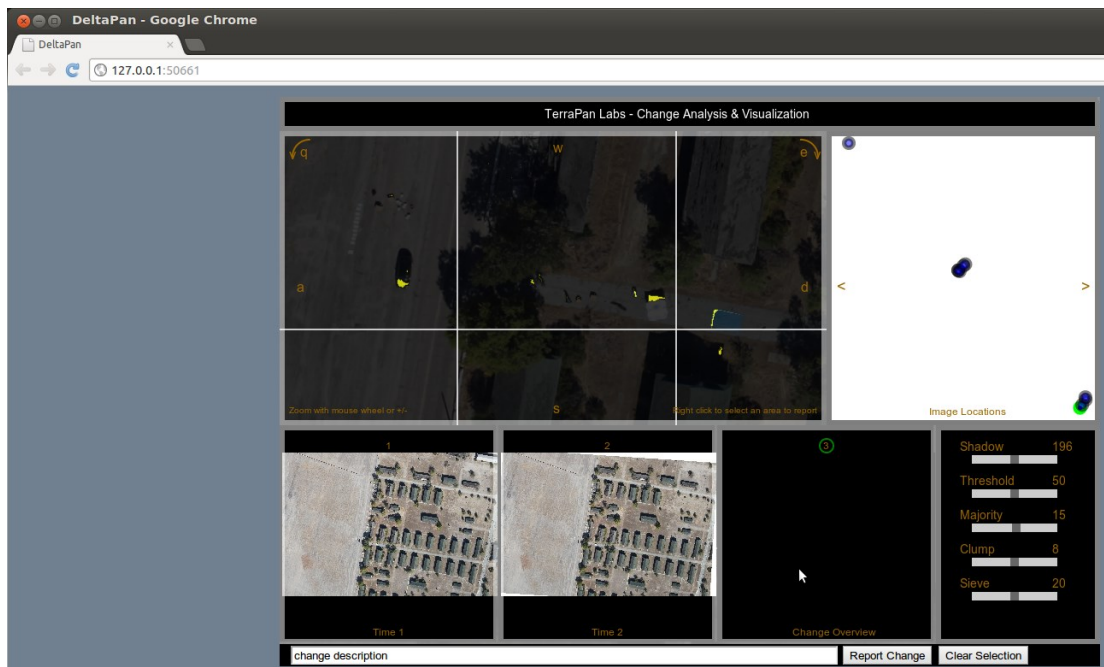

Figure 3. Review of change detection result in web-based change detection and visualization tool. The white box to the right shows the location of the change on a map when connected to high speed internet, but was turned off at RELIEF.

Pass 1

Pass 2

Change

Figure 4. Change detection example from repeat pass images collected
Wednesday August 15, 2012.

Pass 1

Pass 2

Change

Figure 5. Change detection example from repeat pass images collected
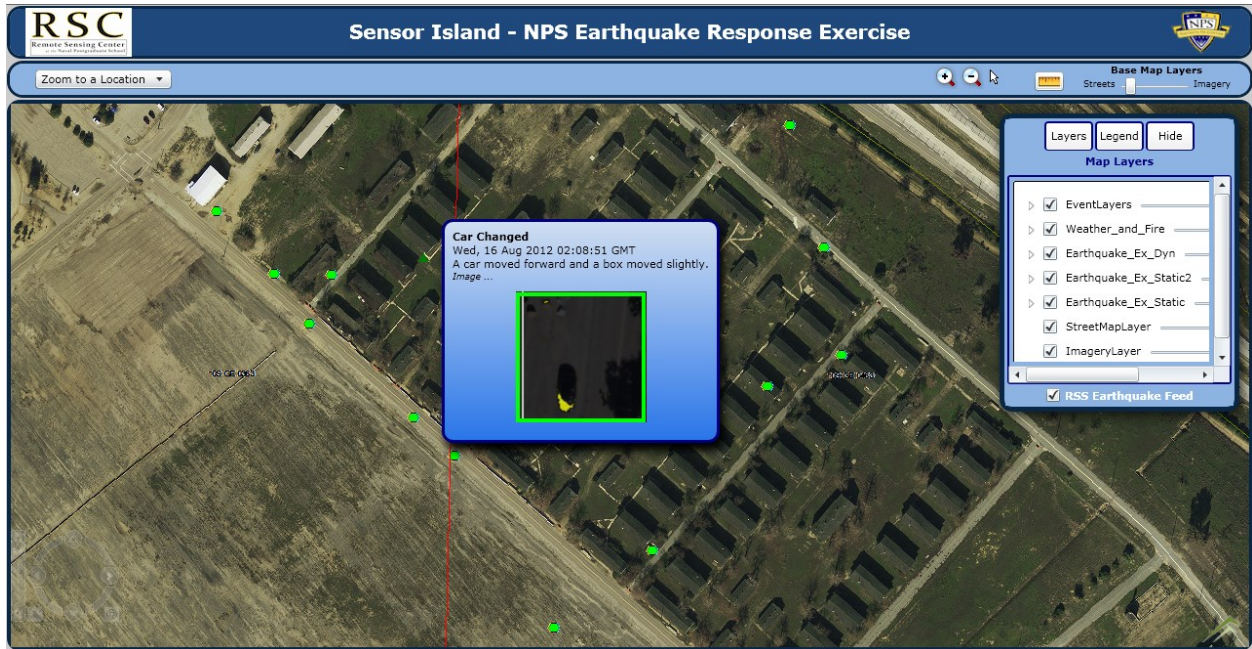Thursday August 16, 2012.

Figure 6. Example of SDSU's image-based change detection product in the common operating picture.

Figure 7. SDSU and other participants gathered for the NPS Post Event Imagery and Lidar Analysis training session (Training 6).