Geocam Space: Enhancing Handheld Digital Camera Imagery from the International Space Station for Research and Applications

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Handheld astronaut photography of the Earth has been collected from the International Space Station (ISS) since 2000, making it the most temporally extensive remotely sensed dataset from this unique Low Earth orbital platform. Exclusive use of digital handheld cameras to perform Earth observations from the ISS began in 2004. Nadir viewing imagery is constrained by the inclined equatorial orbit of the ISS to between 51.6 degrees North and South latitude, however numerous oblique images of land surfaces above these latitudes are included in the dataset.

While unmodified commercial off-the-shelf digital cameras provide only visible wavelength, three-band spectral information of limited quality current cameras used with long (400+ mm) lenses can obtain high quality spatial information approaching 2 meters/ground pixel resolution. The dataset is freely available online at the Gateway to Astronaut Photography of Earth site (http://eol.jsc.nasa.gov), and now comprises over 2 million images. Despite this extensive image catalog, use of the data for scientific research, disaster response, commercial applications and visualizations is minimal in comparison to other data collected from free-flying satellite platforms such as Landsat, Worldview, etc. This is due primarily to the lack of fully-georeferenced data products – while current digital cameras typically have integrated GPS, this does not function in the Low Earth Orbit environment.

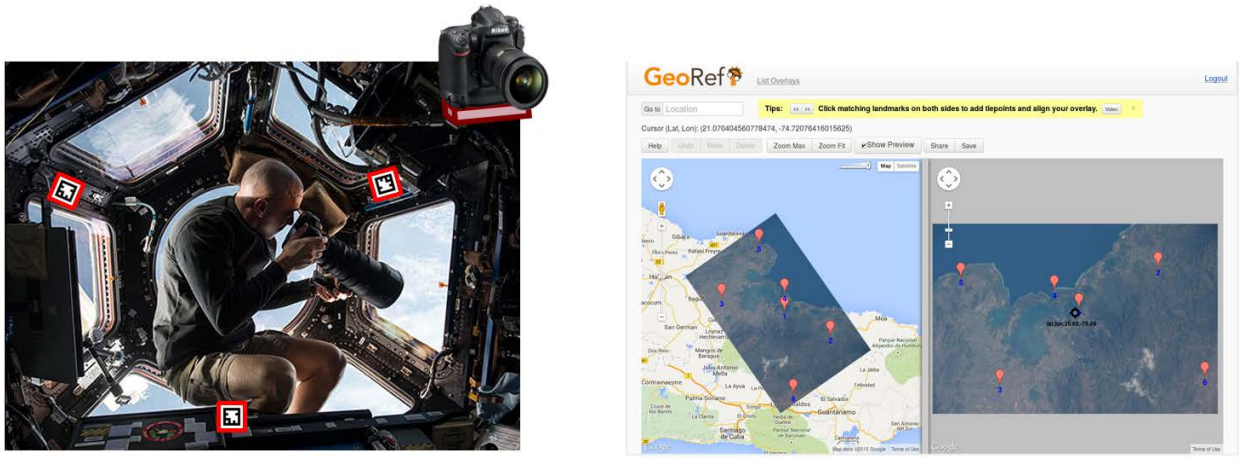
The Earth Science and Remote Sensing (ESRS) Unit at NASA Johnson Space Center provides training in Earth Science topics to ISS crews, performs daily operations and Earth observation target delivery to crews through the Crew Earth Observations (CEO) Facility on board ISS, and also catalogs digital handheld imagery acquired from orbit by manually adding descriptive metadata and determining an image geographic centerpoint using visual feature matching with other georeferenced data, e.g. Landsat, Google Earth, etc. The lack of full geolocation information native to the data makes it difficult to integrate astronaut photographs with other georeferenced data to facilitate quantitative analysis such as urban land cover/land use classification, change detection, or geologic mapping. The manual determination of image centerpoints is both time and labor-intensive, leading to delays in releasing geolocated and cataloged data to the public, such as the timely use of data for disaster response.

The GeoCam Space project was funded by the ISS Program in 2015 to develop an on-orbit hardware and ground-based software system for increasing the efficiency of geolocating astronaut photographs from the ISS (Fig. 1). The Intelligent Robotics Group at NASA Ames Research Center leads the development of both the ground and on-orbit systems in collaboration with the ESRS Unit. The hardware component consists of modified smartphone elements including cameras, central processing unit, wireless Ethernet, and an inertial measurement unit (gyroscopes/accelerometers/magnetometers) reconfigured into a compact unit that attaches to the base of the current Nikon D4 camera - and its replacement, the Nikon D5 - and connects using the standard Nikon peripheral connector or USB port. This provides secondary, side and downward facing cameras perpendicular to the primary camera pointing direction. The secondary cameras observe calibration targets with known internal X, Y, and Z position affixed to the interior of the ISS to determine the camera pose corresponding to each image frame. This information is

recorded by the GeoCam Space unit and indexed for correlation to the camera time recorded for each image frame.

Data – image, EXIF header, and camera pose information – is transmitted to the ground software system (GeoRef) using the established Ku-band USOS downlink system. Following integration on the ground, the camera pose information provides an initial geolocation estimate for the individual film frame. This new capability represents a significant advance in geolocation from the manual feature-matching approach for both nadir and off-nadir viewing imagery. With the initial geolocation estimate, full georeferencing of an image is completed using the rapid tie-pointing interface in GeoRef, and the resulting data is added to the Gateway to Astronaut Photography of Earth online database in both Geotiff and Keyhole Markup Language (kml) formats.

The integration of the GeoRef software component of Geocam Space into the CEO image cataloging workflow is complete, and disaster response imagery acquired by the ISS crew is now fully georeferenced as a standard data product. The on-orbit hardware component (GeoSens) is in final prototyping phase, and is on-schedule for launch to the ISS in late 2016. Installation and routine use of the Geocam Space system for handheld digital camera photography from the ISS is expected to significantly improve the usefulness of this unique dataset for a variety of public- and private-sector applications.



SPACE SEGMENT
Sensor package
&
Targets
GeoSens

GROUND SEGMENT
Geolocation software
GeoRef

Figure 1. The Geocam Space system is split into on-orbit hardware (GeoSens; left) and ground software (GeoRef; right) components.