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Create Accurate Orthophotos with Softcopy Photogrammetry

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Satellite Photogrammetry

Satellite photogrammetry has been a major step forward in the mapping sciences because it is possible to map large areas with very few images (frames). Also, satellite orbits are very stable and have been modeled precisely allowing for the exterior orientation to be calculated and packaged into the image header file. These sensors still require the focal length to be known and ground control is useful for high accuracy projects, but the time savings are tremendous compared with aerial photography. SPOT has been the most widely used stereo sensor and DEM's and orthoimages can be created that have an accuracy of 10m in the X,Y and Z. However, the 10m pixel size has made their utility limited. Several other satellites, both optical and RADAR are available for use in photogrammetry packages, but the level of expertise required to create accurate products is often intimidating to many would be users. With most modern software packages, it is possible to take almost any stereo imagery and process it into stereo models if there is enough information about the sensor and enough ground control.

The IKONOS satellite operated by Space Imaging is a unique sensor that has a very complex sensor model. In the case of IKONOS and most satellite remote sensors, the perspective center is constantly changing as the satellite is moving, therefore we have to move away from the idea of instantaneous snapshots of data and into a linear, constantly changing mode of data collection. To provide users of IKONOS stereo imagery with a camera model, Space Imaging has developed a Rational Polynomial Camera (RPC) which is a header type file that expresses the camera model as a ratio of two cubic polynomials. It was derived from the physical camera model during on orbit calibration of the sensor. The stereo imagery I have seen from IKONOS is of very high quality and once commercial vendors began to incorporate the RPC model into their software, and when Space Imaging makes stereo imagery available for purchase to the general public, we will have a very powerful tool for DEM generation and 3-D GIS data capture. Space Imaging will report at the 2001 ASPRS conference that horizontal accuracy's of 2.0m (CE90) and 3.0m (LE90) will be possible with a single stereo pair using ground control. (Gene Dial, personal communication). Given the fact that IKONOS collects stereo imagery on the same orbital pass (each image within seconds of one another in reality), traditional problems of scene illumination and scene content are eliminated. Currently LH Systems SOCET SET , Z/I Image station and ERDAS Orthobase(in beta) support the IKONOS RPC sensor model.

Ground Control

Ground control in photogrammetry is an essential part of producing accurate exterior orientations, DEMS's and orthophotos. Photogrammetry is an excellent way to bring the power of survey grade GPS into your GIS database and highly accurate orthophotos are a good investment. Always tie your photogrammetry projects into the NGS National Spatial Reference Network so that your data can be a part of the national framework. Generally, ground control points are precisely surveyed pixels that are clearly visible in the image. Ideally, survey crews deploy black and white tarps or striping that are sufficiently large to be clearly visible in the source imagery. Alternatively, manmade or natural features can also be used. Pavement stripes, manhole covers or even individual shrubs can be used. Survey crews precisely survey the middle of the panel using conventional survey techniques or GPS and the RMS accuracy of these points can incorporated into the photogrammetric solution as weights or sigma's. The control points can be referenced to a local grid system or be referenced to geodetic Lat/Long, although I would not recommend doing photogrammetry projects in degrees.. Elevations of control points can be in mean sea level or in height above ellipsoid depending on the survey methods employed. If you are contracting for any part of the photogrammetric process, it is imperative to establish a project vertical datum at the onset. Control points can be vertical only, horizontal only, or both depending on the quality of the survey. Ideally control point networks should be designed so that an individual point is visible in as many images as possible. If existing orthophotos and DEM's are available and are of sufficient accuracy, these may be used as control sources. A good paper on deploying targets for satellite photogrammetry can be found at NASA Stennis Space Center (http://www.crsp.ssc.nasa.gov/vv/Hopi/Hopi-FullFieldOfViewGeodeticTargetRange-98SymposiumPaper.pdf) .

Aerial Triangulation

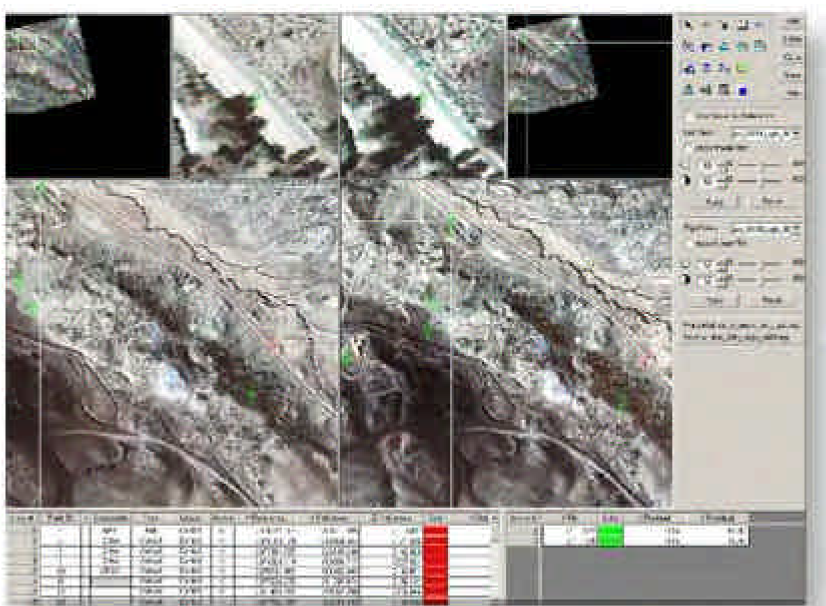

Figure 4.
Screen capture from ERDAS Orthobase ground control measurement module.

The technique of aerial triangulation is used to reduce the number of control points required, achieve higher accuracy across the entire project area, ensure a good edge-match between photos, and to create additional control points through control point extension. Aerial triangulation is also known as block adjustment, bundle adjustment and triangulation. Essentially, the known points (ground control points) are used to establish a geometric relationship between the unknown interior orientation, exterior orientation and a set of points that are measured on at least two images, known as "tie points." These tie points have an unknown X,Y, and Z coordinate before triangulation, but are calculated during aerial triangulation to add additional control mathematically. After a successful aerial triangulation, the following results are available:

- the exterior orientation parameters of each image

- the interior orientation parameters of each parameter
- the X, Y and Z tie point coordinates
- the residuals of the control points
- the image coordinate residuals

All of these results are used to determine the overall accuracy of the block, the statistical robustness of the solution, and as input parameters to do the following:

- create stereopairs for 3-D feature collection
- to measure distances, angles and elevation directly from the source imagery
- to create DEM's using autocorrelation
- to perform orthorectification.