

Emerging Trends in Mapping using LIDAR and Digital Camera Systems

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The emerging technologies of airborne laser mapping and digital imagery compete directly with the older technologies of ground surveying and photogrammetry. A laser imaging distance and range (LIDAR) system, which measures terrain directly, can be integrated with a Digital Camera, and an Inertial Measurement Unit (IMU) and GPS to calculate the exact position of the sensors at the time of data acquisition. Therefore, the need for ground control panels, film development and stereo plotting are eliminated for map generation.

Laser generated data greatly exceeds traditional survey resolutions, with an average sample density of 100,000 points per square kilometer. Achieving this sample density with any other method is normally cost prohibitive.

This paper will delineate the advantages of both LIDAR and Digital Cameras. It will also provide the user with the knowledge of what to specify during data acquisition and how to select a vendor or data acquisition system capable of delivering that data.

Demand for Data

The advancements made in Geospatial Information Systems (GIS) in the last decade have created a large demand for three-dimensional digital data. The most affordable method of obtaining location and elevation data for ground terrain, man-made objects, and vegetation is through remote sensing. LIDAR provides a cost effective solution for obtaining elevation data and Digital Imaging (running the spectrum from panchromatic thru Hyperspectral) provides for classification of surface objects. The ideal solution for capturing this data is a single platform capable of obtaining LIDAR and digital imagery simultaneously.

Applications

LIDAR

LIDAR technologies play a crucial role in the development of high-resolution topographic maps and digital terrain models. Present LIDAR systems essentially paint the surface with a near infrared laser beam, collecting a dense cluster of elevation points with accuracies on the order of 15 centimeters and greater. In maintaining such vertical accuracies the user is left with reflectance images that contain the elevations of the background natural terrain and everything from vegetation cover (trees & shrubs) to man-made features (roads, bridges, building footprints, utility structures, cars and trucks). LIDAR data processing provides a unique challenge in the identification, delineation and removal of cultural and vegetation surface features, for the purposes of generating highly accurate bare earth digital terrain surfaces.

Presently most commercial LIDAR applications have focused on supporting the generation of two-dimensional data sets (surface generation for the development of digital orthophotography and the generation of digital contours). Most commercially available software is overwhelmed by the large volumes of data generated by LIDAR systems, and by its complex data processing requirements. Little attention has been paid to the extraction of digital elevations outside the context of a bare earth surface. Thus a whole set of surface features that include cultural and vegetation cover elevations are being treated more as a nuisance than legitimate 3-D digital elevation features. Our experience has shown us that LIDAR data processing and analysis is a function of the following factors:

- Terrain Roughness
Flat to mountainous terrains
- Types of Earth Surface Features
Natural features (water bodies, vegetation, and geomorphology)
Cultural Features (buildings, roads, utility structures, ditches, etc.)
- Vegetation Density
Low to high-density vegetation
- Mixed Terrain and Surface Features
Heavily vegetated mountains
Vegetated rolling terrain
Urban areas
- Spatial Resolution of the LIDAR data
Point spacing and resolution

Digital Imagery

Airborne digital camera systems are becoming more common and are expected to grow rapidly in the next three years. Digital imagery offers many advantages over film-based cameras. There is a great savings in time because the data can be moved directly to a computer for processing, as there is no need for film processing and scanning. Ortho rectified imagery is available in hours instead of days that allows for rapid response.

The digital camera has a greater dynamic range over film so that shadows can be eliminated and radial balancing is easier. This also allows for more flying days under varying cloud conditions and more flying hours in a day.

The lenses on digital sensors produce a flatter or less distorted image. A myriad of affordable lenses allow the user to control the field of view and pixel size at a given altitude in order to tailor the imagery to specific project requirements or marry the imagery with other sensors. The longest focal lengths

provide the ability to narrow the field of view and produce imagery with less relief displacement than possible with conventional sensors.

Hyperspectral Imagery

Airborne Hyperspectral Imaging is a new tool that can be used to map specific materials. As sunlight is reflected off the surface of materials it is received by the sensor in more than 100 different bands or channels. The combination of specific bands produces a unique signature for each material in the scene. These signatures are used to classify/identify the materials present at each location. It is therefore an excellent tool for environmental assessments, mineral mapping and exploration, vegetation communities/species and health studies, and general land management studies.

This imagery is especially powerful when combined with LIDAR points or the LIDAR generated surface. For example the extraction of forest canopy heights can be accomplished using a combination of hyperspectral classification and LIDAR based multiple return analysis techniques. The resultant hyperspectral vegetation classification could be used to generate polygons that exhibit the exact locations of forest canopy areas. It should be noted that these areas contain both forest canopy and ground elevation points.

The extraction of ground points within the heavy forest areas are conducted using multiple return analysis techniques. Such areas cannot be readily mapped using traditional photogrammetric techniques. Using a set of Boolean based decision rules, MRA techniques, cross-sectional and 3-D profiles, a generalized terrain model is created and used to identify non bare-earth points and retain points that represent the ground surface. The result is a bare-earth surface, and LIDAR points that are representative of the forest tree canopy and their associated heights.

Summary

LIDAR combined with additional imaging products is the emerging mapping technology of the new millennium. The products from these tools can be directly used in a GIS environment to represent not only the terrain but manmade and natural features as well.