Digital Ground Surface Datasets

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Outline

- Overview of Digital Elevation Models
- Sources of Elevation Data
  - Satellite
  - LiDAR
  - IFSAR
- Sava River DEM Processing
- Making Improvements to the existing DEM
- Future alternative DEM collections
Digital Elevation Models

- A digital elevation model (DEM) is a digital representation of ground surface topography or terrain
- DEM’s are most frequently created using remote sensing rather than direct survey
- DEM’s are usually represented as a raster dataset (GRID)
- The pixel values in a DEM are the elevation at that location
DEM Examples

DEM Shade Relief

Color Ramped DEM
Top: Digital Surface Model (DSM)
Bottom: Digital Elevation Model (DEM)
Satellite Triangulation

- Acquire stereo pair of images containing rational polynomial coefficients (RPC)
Satellite Triangulation

- RPC information include:
  - Scan resolution
  - Sensor orientation
  - Camera focal length
  - Satellite flying altitude

- This information are used to generate tie points and calculate the stereo image pair relationship
Satellite Triangulation

- Common points from the stereo pairs are used to calculate an elevation at that point based on sensor geometry and ground truth.

- Output DEM is generated as a raster.

- Accuracy of DEM elevation from this method is good when sensor geometry and ground truth calibration are available.

- Reported vertical accuracies are approximately 15 meters.
LiDAR

- Light Detection and Ranging
- Laser altimetry
- Airborne laser scanning
- Lidar
LiDAR Components

- Laser
- IMU (INS)
- GPS
- On-board computer
Lidar – What does it do?

- Records distance to target
  - Time * speed of light / 2

- Typical wavelengths:
  - 1064-nm
Most commercial systems today are:

- Small footprint
- Multiple return
- Collecting visible imagery simultaneously
Commercial System Error Budget

- Laser rangefinder = 2-3 cm
- GPS error = 5-10 cm
- IMU error = 0.27 @ 10,000 ft
  - Usually flown around 2,000 ft
- Vendors may quote (depending on system configuration):
  - 15-18 cm vertical accuracy
  - 0.5-m horizontal
10-meter DEM from contours

12-foot DEM from Lidar
Summary

- On average, the absolute accuracy of Lidar-based elevation data is ~ 15-cm; relative accuracy can be less than 5-cm.

- Absolute accuracy of the x-, y-data is dependent on operating parameters such as flight altitude; however, it is usually 10's of cm to 1-m.

- Elevation data generated at thousands of points per second, resulting in elevation point densities far greater than traditional ground survey methods.

- One hour of data collection can result in over 10 million individually geo-referenced x-, y-, z-points.

- It is possible to rapidly complete a large topographic survey and still generate DTMs with a grid spacing of 1-m or less.
Interferometric Synthetic Aperature Radar (IFSAR)

- Airborne or satellite synthetic aperture radar (SAR) systems
- Two radar data sets collected at the same time but separated by a fixed distance (two antennae)
- Ground elevation is calculated by the amount of time it takes for the radar signal to return
Shuttle Radar Topographic Mission (SRTM)
IFSAR Data Specifications

- Airborne IFSAR technology is maturing quickly
  - Sensor development
  - Geo-referencing technologies
  - Computing power

- Can be flown on standard fixed wing aircraft

- Collection of airborne data can be easily coordinated with ground truth collection efforts

- On average, the absolute accuracy of airborne IFSAR-based elevation data is better than 2.5 meters

- Absolute accuracy of the x-, y-data is dependent on operating parameters
  - such as flight altitude; however, it can be approximately 1-m.

- It is possible to rapidly complete a large topographic survey and still generate DTM with a grid spacing of 5-m or less.
Overview Study Area

Slovenia

Croatia

Bosnia Herzegovina

Serbia
Sava Digital Elevation Model

Croatia

Bosnia Herzegovina

Slovenia

Serbia

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Sava DEM

- Derived from satellite image pairs
- Covers the entire length of the Sava River from Eastern Slovenia to Beograd, Serbia
- Includes most of the population centers where the greatest risk of loss of life and property exist
- Spatial resolution is 12 meter
- Reported vertical accuracy (elevation) is < 15 meters
Sava Digital Elevation Model
Sava DEM Processing

- DEM was delivered in raw format and included “data voids” or areas with no elevation information

- Image pre-processing techniques were used to
  - Geo-register DEM tiles to a common projection
  - Mosaic tiles into a seamless DEM

- Data voids were filled using an iterative process of identifying void locations and filling them with elevation data from the SRTM DTED Level 2 dataset

- Output “void filled” DEM was processed further to remove spikes in the elevation data

- The void filled and smoothed DEM is the data that was used for the modeling efforts
Incorporating Bathymetry Data into a DEM

- There is potential to incorporate additional elevation data (bathymetry) into the Sava DEM

- Multi-step processing requirements include:
  - Interpolation of discrete bathymetry point data to a gridded product
  - Up Sample or Down Sample bathymetry grid to match the spatial resolution of the DEM
  - GIS routines to replace DEM elevation values with the bathymetry elevation

- The output DEM would include the original DEM data with the additional bathymetry data for the river
Recommendations for Future Collections

- The elevation data used for this effort were the best available at the time and significantly better than SRTM data.
- Future modeling efforts should include acquiring new high resolution DEM.
- Recommendations for new collections would include:
  - High Resolution Airborne LiDAR
  - High Resolution Airborne IFSAR
- Future collections may be contracted through NGA and InterMap.
Questions?