GEOG 357

LECTURE 18

Lidar

- LiDAR: Light Detection And Ranging
 - also known as airborne laser swath mapping (ALSM)
- Employs a scanning laser range finder to produce accurate topographic surveys of great detail.
- A LiDAR scanner is an active remote sensing instrument
 - transmits electromagnetic radiation and measures the radiation that is scattered back to a receiver.

2

3

4

Lidar

- LiDAR uses radiation in the ultraviolet, visible, or infrared region of the electromagnetic spectrum.
- The scanner is typically carried on a low-altitude vehicle
 - Vehicle has an inertial navigation system and a differential GPS to provide location.
- LiDAR scanners are capable of collecting extremely large quantities of very detailed information

Presentation Title

Lidar

- The data collected from a LiDAR scanner is referred to as a point cloud or mass points
 - Mass points/Point cloud is a massive collection of independent points with (x, y, z) values.
- After initial data capture, further processing is usually required to remove tree canopies, buildings, and other unwanted features and to correct errors in order to provide a "bare Earth" point dataset.







Longley, Goodchild, Maguire and Rhind (2011), Geographic Information Science and Systems





http://oceanservice.noaa.gov/facts/lidar.html

What is LiDAR exactly?

Controlled bursts of LASER (Light Amplification by Stimulated Emission of Radiation)

Distance to object given by TIME

-requires 3 units:

-laser emitter/receiver, -GPS, -IMU (Inertial measurement unit)

Used in 60s-70s for scanlines, feasible for images with the development of GPS (1990s) -now widely available



Laser pulses at up to 50,000 - 200,000 / second Resulting cloud of points: up to 20 points / square metre ~10/sq m needed for forestry 1 / sq m for glaciers (no trees) Horizontal accuracy 50cm - 1m, vertical ~20cm Cloud of points is converted to raster grid ~1metre





'Waveform' returns give distance (heights) for multiple levels: the **only** remote sensing technique able to distinguish between multiple ground layers



http://www.navy.gov.au/laser-airborne-depth-sounder-lads

Range finding LiDAR for topographic mapping

Unaffected by clouds **above** (unlike air photos) .. why?

Laser bursts are emitted usually at one of these wavelengths:

>355 nm (UV): wind, water vapour
>532 nm (green): bathymetry
>1064 nm (Near IR): surface mapping
..... (why these ??? *)

LiDAR - 1064 nm, 532nm, 355nm -why those wavelengths?

Lasers produce light the same way as a neon sign - a substance is stimulated to an excited state, causing the release of extra energy as a photon of light.

Nd:YAG (*neodymium-doped yttrium aluminium garnet*) is a crystal that is used as a lasing medium for solid-state lasers. It emits at a wavelength of 1064 nm.

According to the Planck-Einstein equation:

$$E = \frac{hc}{\lambda}.$$

Where h= Planck's constant, and c = the speed of light; halving the wavelength, has the effect of doubling the energy released, and one-third the wavelength (355) triples the energy (= the second and third harmonics)





Volume estimation: Ground Zero, World Trade Centre site, New York Post September 2001

http://www.volker-goebel.de/Lidar.html





Vegetation: Tree Canopy Height

http://quake.wr.usgs.gov/research/geology/lidar/example2.html

 Air photo
 Vegetation surface DSM
 Bald Earth Model (BEM)

 Vegetation height = DSM minus BEM)

Aleza Lake Research Forest

Oldest research forest in BC, jointly operated by UBC and UNBC 60km north-east of Prince George







LiDAR reveals both 'bare earth' (ground) and canopy height

UNBC LiDAR datasets: UNBC campus, Aleza Lake RF, JPRF, Ancient Forest

LiDAR Data Products

Mass points detailing elevation can be converted into:

- Bare Earth Model (BEM)
- Slope, Aspect, and Hillshade models
- Canopy Surface Model

Numerical models can be built to estimate: - Species, volume, dbh, biomass



Canopy Surface Model shaded relief draped on DEM



Canopy Height = Canopy Surface - Bare Earth





Hillshade Model Hansard Creation Hansard Creation Hansard Creation Hansard Creation Hansard Creation Hillshade Model built for conventional BC DEN Hillshade Model built for conventional BC DEN



Tree Stem Maps Individual tree crowns are discernable from the Canopy Height Model so *Roger et al* developed a tree finding algorithm to identify tree stem locations



Vegetation Data Products LiDAR Data - tree stems



Tree Stems (displayed by tree height)



29



Tree Stems (displayed by crown shape)

Forests for the World orthophoto





City 1 metre DEM (from 1m contours)



33



LiDAR Platforms

Airborne since 1970s e.g. Optech (Ottawa) NorthWest Geo (Calgary)

And many others ... including UNBC (Brian Menounos) - LiDAR is mostly airborne, while RADAR is mostly spaceborne

Spaceborne

ICESat (Jan 2003->2009): Geoscience Laser Altimeter System (GLAS):

66m 'footprint' and 10cm vertical resolution, designed for polar icecaps

ICESat2 (Sept 2018): <u>https://icesat-2.gsfc.nasa.gov</u>



CALIPSO: Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation

LiDAR summary

Present drawbacks: (all reducing with technology increase)

- o The relative high cost of collecting LiDAR
- o High data volume Terabytes
- o Steep learning curve in research and understanding

(involving utilizing the entire point cloud)

LiDAR summary

Advantages:

- ✓ Very high resolution DEM for many applications
- ✓ All urban areas with flooding potential
- $\checkmark~$ Multi-layer data for forestry and ecosystems
- ✓ Increasing data supply some free download
- ✓ Increasing conference content in GIS/RS/Cartography/Forestry
- ✓ Many online resources e.g.:

USGS: http://lidar.cr.usgs.gov/knowledge.php

BC CARMS: http://carms.geog.uvic.ca/carmslidarnew.html

Ground based - 'terrestrial' Lidar

Lidar-based rock-fall hazard characterization of cliffs



Figure 1. (a) Image of a 2009 rock-fall in Yosemite National Park with (b) point cloud and (c) surface model of the source area. Brightest-blue colored areas of surface model in (c) indicate areas of change following the rock fall.

LiDAR imagery of Gaping Gill - Britain's largest cavern

http://www.nps.gov/yose/naturescience/upload/Collins-Stock-2012-ASCE.pdf



Fig. 1: Gaping Gill Main Chamber LIDAR survey 2003. Vertex cloud looking west.

Fig. 2: Gaping Gill Main Chamber LIDAR survey 2003. Vertex cloud looking east.

Video: http://www.youtube.com/watch?v=8HdgliagAds

Heritage building scanning: http://www.youtube.com/watch?v=4AGk01Ims5k



Conference group photo (RW in red jacket, front centre)

Conference group LiDAR scan image



LiDAR DEM, ~2017 - glaciers in Monkman provincial park - Geographically the closest glaciers to PG









ALOS DEM ~2010 30m resolution



LIDAR DEM 2017