Exploratory Work to Understand the Potentials and Limits of LiDAR Points Cloud Data

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Introduction

- LiDAR (Light Detection and Ranging or Laser Imaging, Detection and Ranging)
  - Active optical remote sensing technology
  - Measures properties of scattered light to find range and/or other information of a distant target
  - Records dense points of the 3D position of the ground, overlying vegetation, and other built features
- LiDAR Data are Useful to:
  - Derive high-resolution digital elevation models (DEMs) that are used in wide range of scientific and engineering applications, including hydrologic modeling, terrain analysis, and infrastructure design
  - Derive the data on crop and field boundary height and canopy height and structure that are useful for animal habitat modeling and plants distribution planning
  - Enable assessing natural hazards and resources by enabling the precise measurement of earth movement associated with faults, landslides, volcanoes, and fluid pumping
  - Enable building detection and 3D modeling
- Our Extensive Use of LiDAR Data
  - Geospatial analysis using LiDAR-derived DEMs
  - Assessment of complex sites using the initially processed LiDAR points before further processing

Issues and Ongoing Work

- Current Issues
  - Points are the native, resolution-independent format of LiDAR, but working with massive point data sets (e.g., 0.2 billion points for covering Blacksburg, VA) often overwhelm system memory and data processing time
  - Lack of tools, such as merging, tiling, filtering, classifying, to process LiDAR data in Linux-based HPC systems
- Ongoing Work
  - **For Geospatial Analysis and 3D Modeling**
    - Countywide scale: Using single workstation based LiDAR data processing tool (e.g., LAStools)
    - Statewide or nationwide: Exploring other opportunities to leverage Linux-based HPC cluster systems; e.g., NSF funded OpenTopography and CyberGIS projects
  - **For Assessment of Complex Sites**
    - Leverage Human Visual Perception
      - ✓ Intuitively extract only the partial data of interest by navigating the data space before full processing
      - ✓ Minimize the system resource and time before full data processing
    - Leverage Virginia Tech ARC resource and open source projects
      - ✓ Visionairum lab's VisCube immersive VR facility
      - ✓ Keckcaves's Vrui, LidarPreprocessor and LidarViewer

Conclusion

- Potentials
  - LiDAR-derived high-resolution DEMs can help more accurate analysis tasks, than using the existing DEMs provided by USGS
  - First-person view in the VisCube (immersive VR system) allows users to explore the data intuitively and to help get deeper insight from the data
- Limitations
  - Need a data-processing pipeline leveraging parallel computing for processing LiDAR data at larger scale
  - To effectively leverage human visual perception, more intuitive 3D user interfaces and interaction techniques are required
  - Navigation in the VisCube is getting slow when using the actual scale even with several hundred million points

High-Performance Visualization and Geospatial Applications

- Terrestrial LiDAR

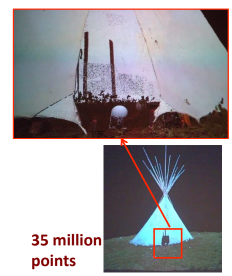
Useful for collecting very dense and highly accurate points, which allows precise identification of objects. These dense point clouds can be used to manage facilities, conduct highway and rail surveys, and even create 3D city models for exterior and interior spaces

Visualization of Points Cloud of Multiple Sites (ICAT, ARC)

- ✓ **Points data:** Using FARO 3D scanner technology, the rich amount of points cloud with RGB from multiple angles were collected.
- ✓ **Data Processing: Clean** the points → **Construct** octree-based data structure of the points → **Display** the preprocessed LiDAR data using LidarViewer in the VisCube.

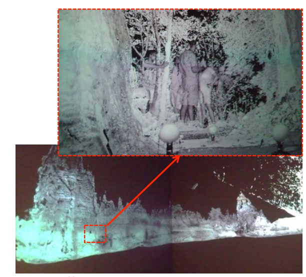
115 million points

Basilica site of St. Denis in Paris , 2013



35 million points

Tepee, Blackfoot Crossing Historical Park in Siksikia, Canada. 2013



386 million points

Cave outside Jinan, China. 2014

- Airborne LiDAR

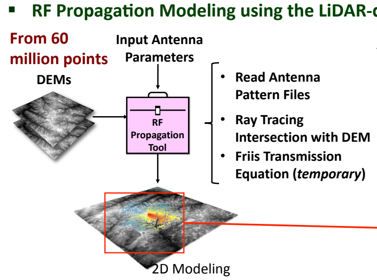
: Useful for deriving surface models for use in many applications, such as forestry, hydrology, geomorphology, urban planning, landscape ecology, coastal engineering, survey assessments, and volumetric calculations

Visualization of Points Cloud of Blacksburg, VA (CGIT, ARC)

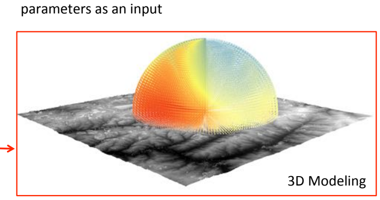
- ✓ **Extract** the points for the area of Blacksburg → **Map** the satellite image onto the points → **Construct** octree-based data structure of the points → **Display** the preprocessed LiDAR data using LidarViewer in the VisCube.

20 million points

RF Propagation Modeling using the LiDAR-derived DEMs (CGIT)

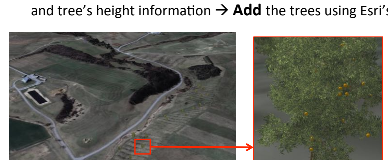


- ✓ **Derive** high-resolution DEMs with 5 ft. x 5 ft. cell size → **Generate** coverage estimates relative to the DEMs, using transmitter antenna parameters as an input

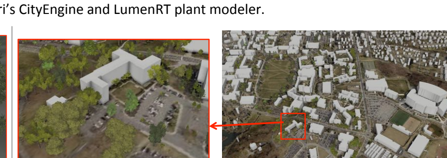


3D City Modeling Using the LiDAR-Derived DEMs, Building Footprints, the Height of Trees (CGIT)

- ✓ **(Left Figure) Extract** the points for the area for the Kentland farm in Blacksburg → **Derive** high-resolution DEMs with 5 ft. x 5 ft. cell size → **Map** the satellite image onto the DEMs → **Add** the trees generated from silvopature data using Esri's CityEngine and LumenRT plant modeler.
- ✓ **(Right Figure) Extract** the points for the area of the Virginia Tech campus → **Derive** DEMs, buildings (without image texture), and tree's height information → **Add** the trees using Esri's CityEngine and LumenRT plant modeler.



Kentland farm



3D Virginia Tech Campus