LIDAR-based Change Detection of North Carolina Coastal Areas

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Abstract:

The long term goal of this project is to discover a robust method of using historical remote sensing data to accurately trace coastal changes along North Carolina's coast over the last decade. By understanding the previous changes, those who study coastal regions can better predict future changes due to hurricanes, etc. As a first step towards this goal, one must make sense of the overwhelming amount of historical data available to answer the important questions of where and when do we possess sufficient overlapping sampling and across what time periods to make meaningful comparisons. This project seeks to address this issue by providing tools to both catalog available historical data, and allow a visual exploration of the generated catalog to identify promising overlapping survey extents.

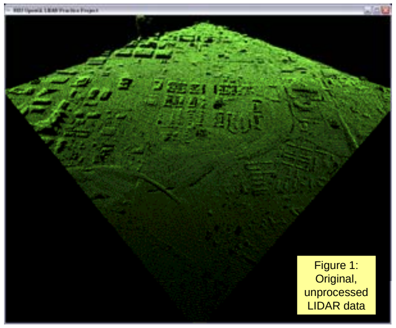

Figure 1: Original, unprocessed LIDAR data

Introduction:

Light Detection and Ranging (LIDAR) is a remote sensing technology that uses laser rangefinders to map the distances to remote surfaces. By combining these rangefinders with GPS systems on an airborne platform, large swaths of terrain can be accurately sampled at high resolutions. The resulting data is then traditionally used to generate topographic maps at high resolutions and derive other geospatial datasets.

NOAA has collected the datasets from LIDAR surveys along North Carolina's coastline spanning over a decade. By developing a method of detecting changes between and across these historical datasets, we can identify and extract the terrain features that have changed over time. These changes can then be related to major events such as hurricanes to identify the event's effects on the coastline. This collection, however, is both tremendously large in terms of overall size and also ambiguous as to the formats, coordinate systems, and extents of the individual datasets contained within. We have developed a set of tools that convert the datasets to a standard format, extract iconic meshes to form a manageable catalog, and finally provide an interactive environment for the exploration of the entire collection. This allows future developers to quickly identify what areas have overlapping samplings across multiple time steps, and are thus excellent candidates to focus on for change detection.

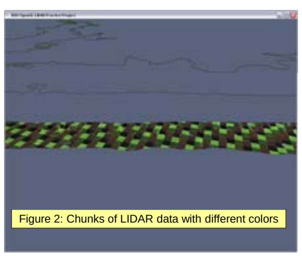

Figure 2: Chunks of LIDAR data with different colors

Setup:

1. The LIDAR data is downloaded from either NOAA's website or other online repositories.
2. The LIDAR data is preprocessed and chunked into a custom file format (.lps) that is highly efficient. Dividing the sample points into rectangular units based on their location makes it easier to catalog and process during change detection.
3. The chunked files are then triangulated to form 3D mesh representations. These meshes are then simplified to multiple levels-of-detail, while preserving boundary edges, as maintaining the coastline's accuracy is an important consideration.
4. The 3D meshes and geospatial vector data such as the state's outline is loaded into our interactive viewer which allows the user to freely explore the overall collection.

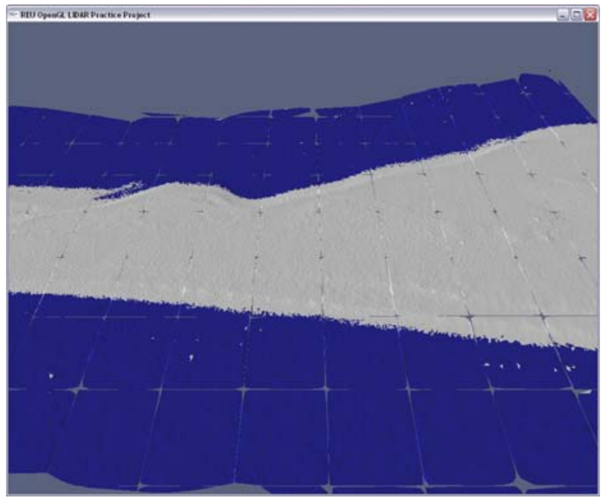

Figure 3: 3D processed LIDAR data with water and land shaded different colors

Research:

LAS File Format

- Integrate the libLas library into existing LIDAR point processing software.
- Determine how to efficiently convert from multiple data formats and coordinate systems into a standard custom format.

New data sets

- Modify existing processing algorithms to generate new levels-of-detail while also preserving the boundary edges (coastline).
- Create an interactive application to allow exploration of multiple datasets.

Results:

- The newer file format for representing LIDAR data, LAS, can be now be loaded and processed.
- All encountered data formats can now be converted to a single standard.
- A new boundary-edge preserving simplification algorithm allows for dramatically smaller meshes while still showing detail along the coastline.
- All of the LIDAR datasets from NOAA can be interactively viewed superimposed along a high resolution vector representation of North Carolina's coastal border.

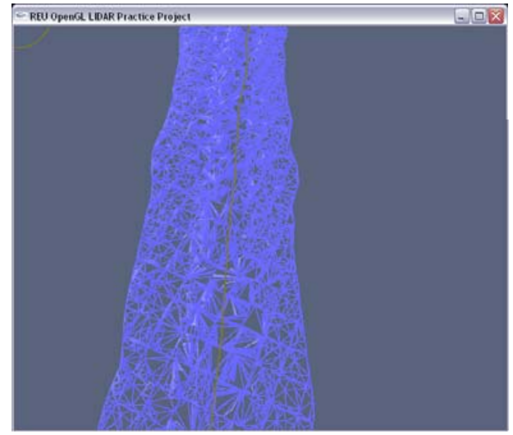

Figure 4: Triangulation of LIDAR data

Conclusion:

We have created tools that form a pipeline that begins with a massive and disorganized collection of historical LIDAR datasets and ends with a standardized catalog of lightweight 3D meshes. Our interactive exploration tool then presents this catalog to the user in a intuitive map-based environment.

Through this experience, I have learned how to work in the Visual Studio environment, the basics of graphics programming using OpenGL in C++, explored mesh simplification, and had lots of experience debugging code.

Future Work:

- Explore methods to reassemble the square simplified meshes into a single mesh for each entire dataset, with minimal detail in the center, but a highly preserved coastline.
- More datasets to be processed through the pipeline and loaded into the LIDAR viewer in order to show the entire coastal area of North Carolina.
- Change detection to produce viewable 3D models of differences between multiple overlapping LIDAR datasets.
- Ability to show these changes over time in a coherent manner.

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