CMSC 401: Project Report
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INTRODUCTION:
The project plans to create two types of models: a bathymetric model and a canopy model, both of which will be based on LiDAR point clouds and TINs. LiDAR is a remote sensing method that uses laser light to determine distances between objects on the Earth's surface. It is frequently used to create exceptionally accurate digital terrain models that may be used for a number of purposes such as flood modeling, infrastructure construction, and resource management.

The project is separated into two major segments in order to fulfill its goals. The initial step is to construct a Triangle PR-quadtree data structure. A quadtree is a tree data structure that is used to divide a space into smaller parts. A PR-quadtree is a quadtree that is used to split planar point sets.A Triangle PR-quadtree is used in this project to split the points of a terrain or surface specified by a set S.

In the first section, a TIN is calculated using a function from the Scipy library. A triangulated irregular network (TIN) is a sort of triangulated irregular network that is used to depict surfaces by linking a collection of points with triangles. After calculating the TIN, the Triangle PR-quadtree data structure is created by extending the data structure for PR-quadtrees. The vertices and triangles from the TIN are then inserted into the Triangle PR-quadtree, and the Triangle PR-quadtree is traversed to print the content of its leaf blocks.

The algorithms created in the first part of the project are used to create a terrain model from LiDAR elevation or bathymetric data in the second portion of the project. The study of the depths and forms of underwater surfaces is known as bathymetry. As a result, underwater surfaces are represented using the bathymetric model. The terrain model is used to compute morphological terrain properties and important places such as roughness, concentrated curvature, and maximas. These characteristics are crucial in understanding the terrain's qualities and may be utilized for a variety of applications, including land management, environmental planning, and disaster management.

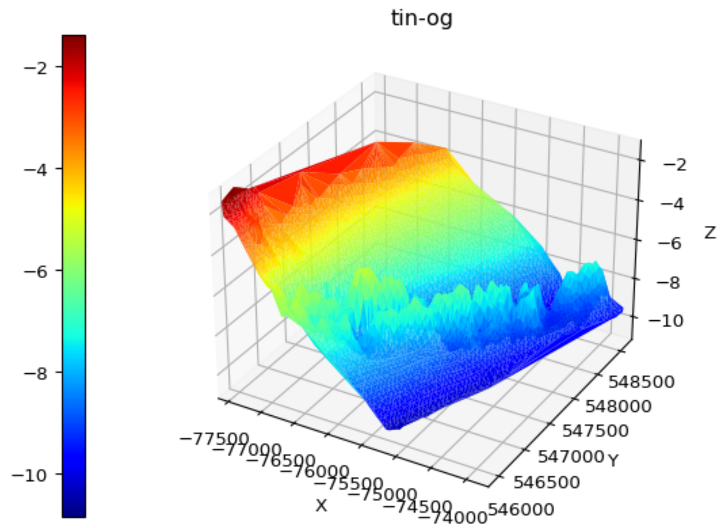
In addition to the topography model, LiDAR data defining a forest is used to create a canopy model. The canopy model is used to detect tree tops in LiDAR data. This is useful for understanding forest structure and composition and may be utilized for forest management and conservation.

Finally, the project's output includes images of the bathymetric data set and canopy points set, which has a capacity of 100.

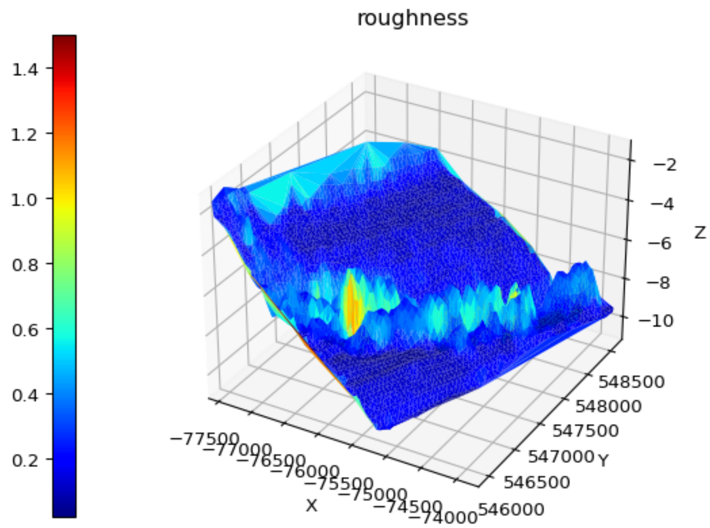
OUTPUT:

TASK-1:
The output of the project includes images of the bathymetric data set with a capacity of 100.

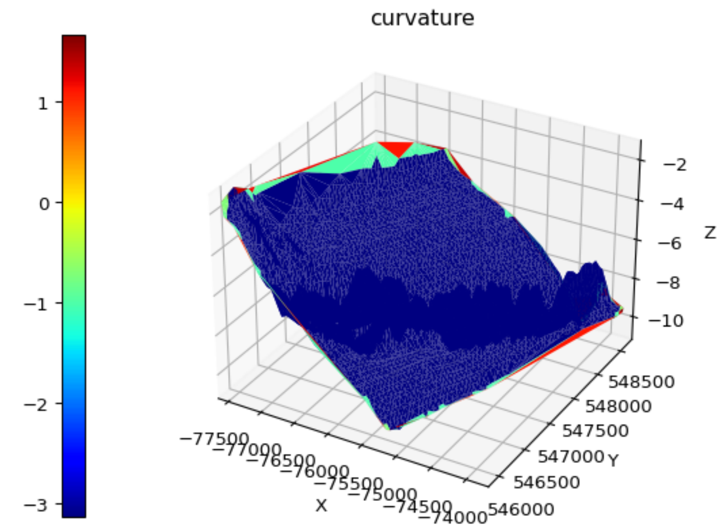
1)Tin generated:



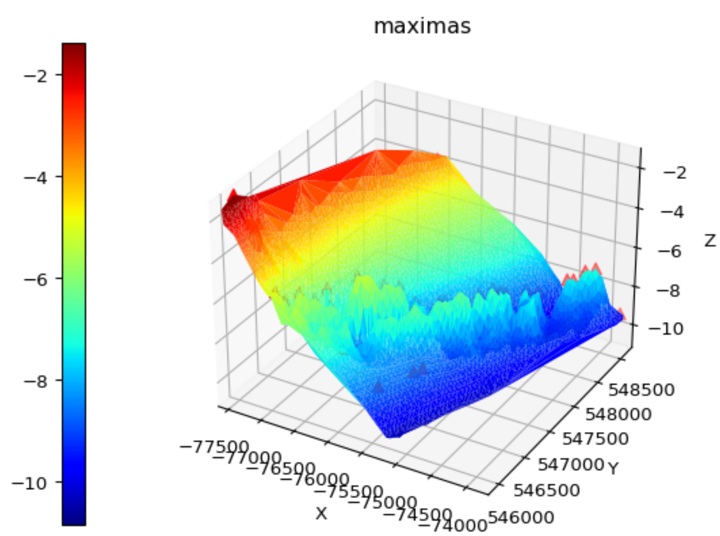
2) Roughness-based colored TIN:



3)Concentrated curvature based colored TIN:

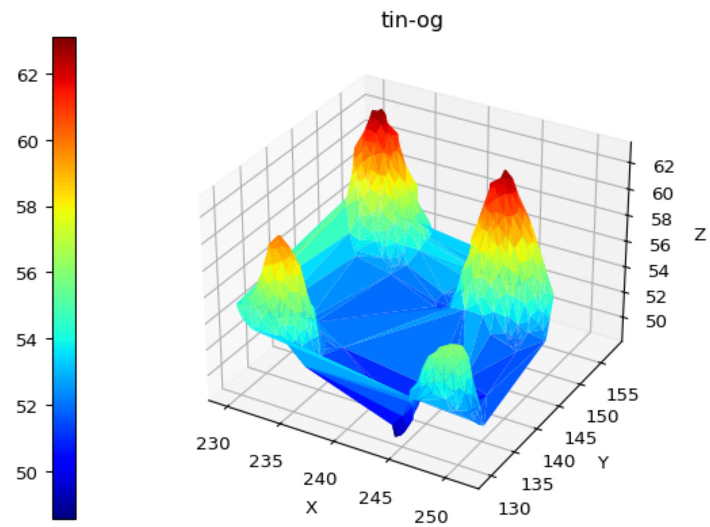


The images for the canopy data set with capacity set as 100: Maximas marked on TIN

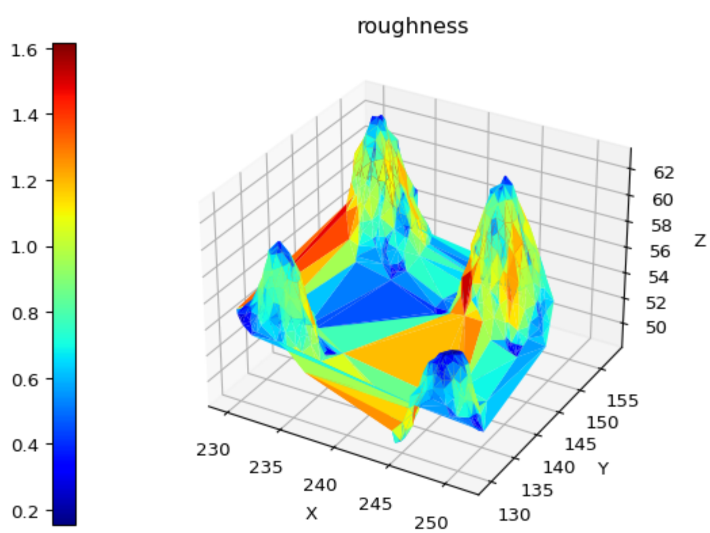


TASK-2:
The output includes images of the canopy TIN with the maxima (tree tops) marked with a capacity of 100.

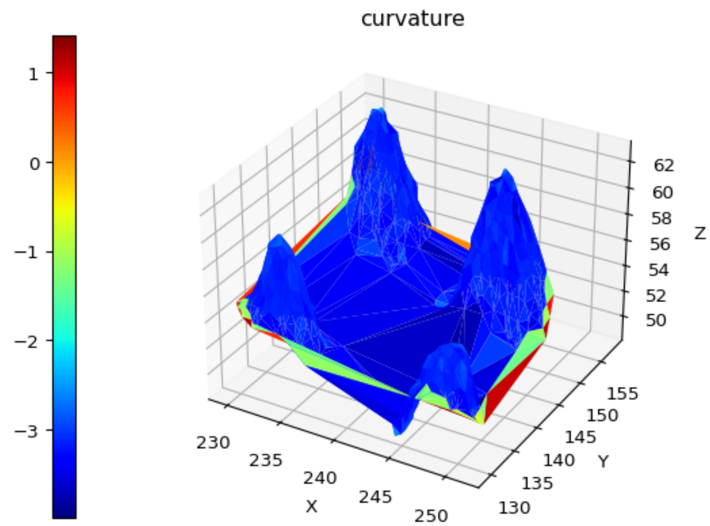
1. **Tin generated:**



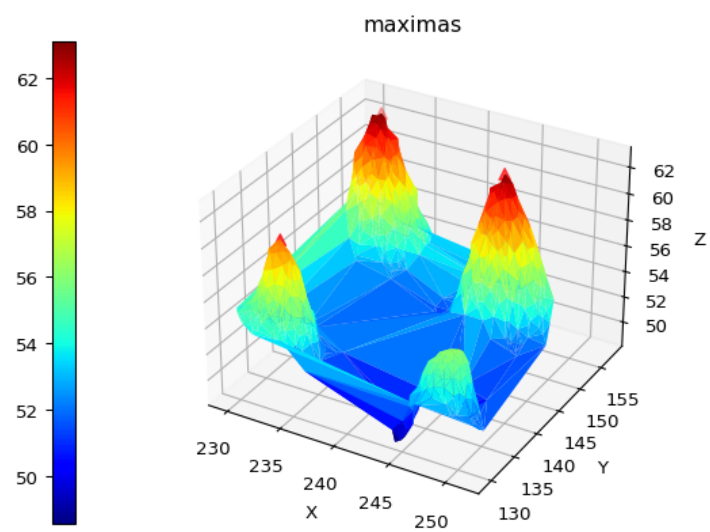
2) Roughness-based colored TIN:



3) Concentrated curvature based colored TIN:



The images for the canopy data set with capacity set as 100: Maximas marked on TIN



Advantages and disadvantages of Triangle-PR quadtree with respect to the project tasks:

Advantages of using Triangle PR quadtree:

- Storage efficiency: The usage of a Triangle PR quadtree enables for efficient spatial data storage, which is critical for huge datasets. This can lead to faster processing times and reduced memory usage.
- Efficient spatial queries: The Triangle PR quadtree provides efficient spatial queries, which is necessary for the project tasks such as calculating roughness, curvature, and maxima.
- Can handle large datasets and can be easily adapted to different resolutions/details: This provides greater flexibility in the analysis of spatial data, as it can be scaled up or down as needed.

Disadvantages of using Triangle PR quadtree:

- Complexity of implementation is high: The implementation of the Triangle PR quadtree data structure is complex, which can require a significant amount of time and resources.
- Updating and modifying data points are harder: Modifying and updating data points can be more challenging with a Triangle PR quadtree than with other data structures.
- Sensitivity to data distribution: The Triangle PR quadtree is sensitive to data distribution, meaning that the performance of the data structure can be affected by how the data points are distributed in 2D space. This can impact the accuracy and reliability of the spatial queries performed with the data structure.

Additionally, the process of finding adjacent vertices and vertex-triangle relations at every node in the Triangle PR quadtree can be time-consuming and complex, which can cause delays in the calculation of roughness, curvature, and maxima for each feature at every node and each of its vertices. Therefore, other data structures such as octrees, DEMs, or R-trees could potentially prove to be more efficient in storage and performance for large datasets.