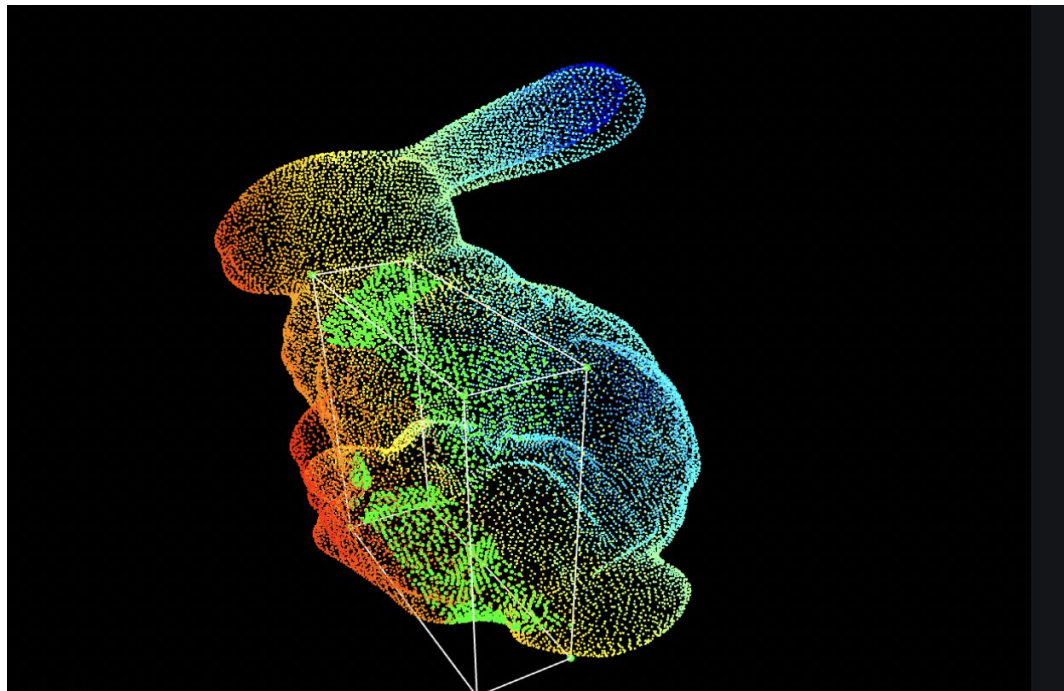


Team 8 - CMPE 255 Research Topic

Real-time Visualization of 3D point clouds



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Introduction to Point clouds

- Simplest form of a 3D model that represent objects or space.
- It is a collection of points plotted on the X,Y,Z axes.
- Each point has several measurements, including the (x,y,z) coordinates, and sometimes additional data such as the color value, and luminance value, which determines how bright a point is.
- Point clouds are created by performing a scan of an object or a structure. Scans are done using either a laser scanner or through a process called photogrammetry.

3D Point Cloud

- Unrefined data coming from sensors.
- Raw 3D point cloud dataset is scanned , processed and then filtered to get all the points within the coordinate system.
- Interoperability,modularity and efficiency is key for collaboration of the points .
- Hundreds of available file formats for 3D modelling.
- Major difference in point cloud file format is the use of ASCII and binary.
 - ASCII -- rooted as binary but characters are focal point of data.
 - Binary - stores data directly in binary code. Eg- .FLS, .PCL , .LAS

A 3D point cloud can be created using following methods:

1. 3D Modelling Software
2. Algorithm
3. Scan



Software



Algorithm



Scan

Point Cloud Dataset Creation using Laser Scanners

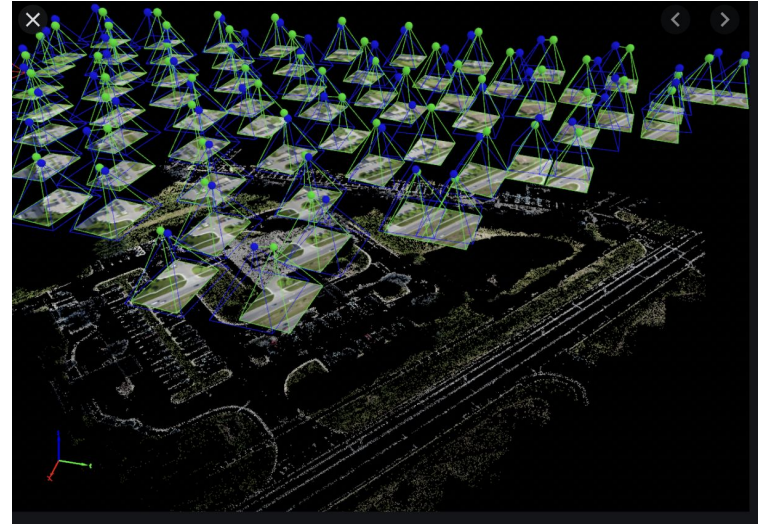
- Laser scanners work by sending out pulses of light to the surface of an object and measuring how long it takes each pulse to reflect back and hit the scanner.
- These measurements are used to find the exact position of a point on the object, and these objects then form the point cloud.

PHOTOGRAMMETRY

- It is the science of making measurements from photographs particularly aerial photographs.

How it works?

- Looks at photographs taken from two or more locations.
- Uses different perspectives of the images along with the location data of where the images are taken.
- The more photographs of the subject from a particular location, the more is the accuracy 3D model.



Applications

1. Construction

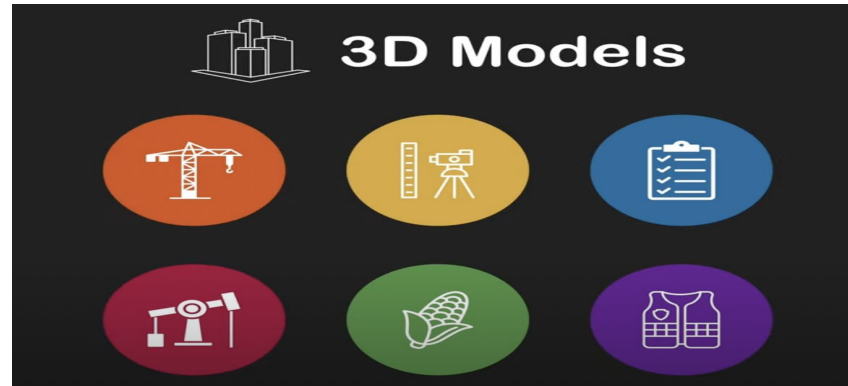
2. Architecture

3. Inspection

4. Energy Firms

5. Agriculture

6. Public Safety

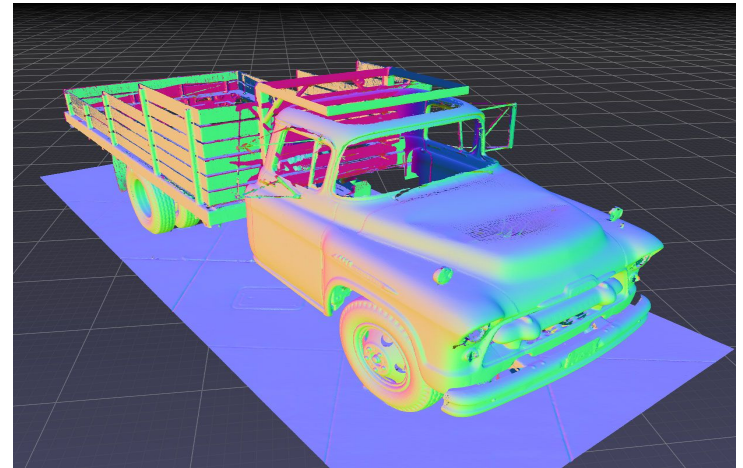


Objective of this research topic

- Visualization of Real World shapes using 3D point cloud datasets.
- Import, visualize and segment point cloud dataset with 60 million+ points of X-Y-Z coordinates using PPTK python library.
- The point information includes Point coordinates and color intensity.
- Feature Extraction, interactive and automatic segmentation on dataset.

Working Environment

- Working with Anaconda Python Environment using Spyder IDE for 3D point cloud visualization.
- 3D point cloud dataset being used created by Photogrammetry.
- The data set contains around 60 million of points.
- WEBGL version of the dataset.



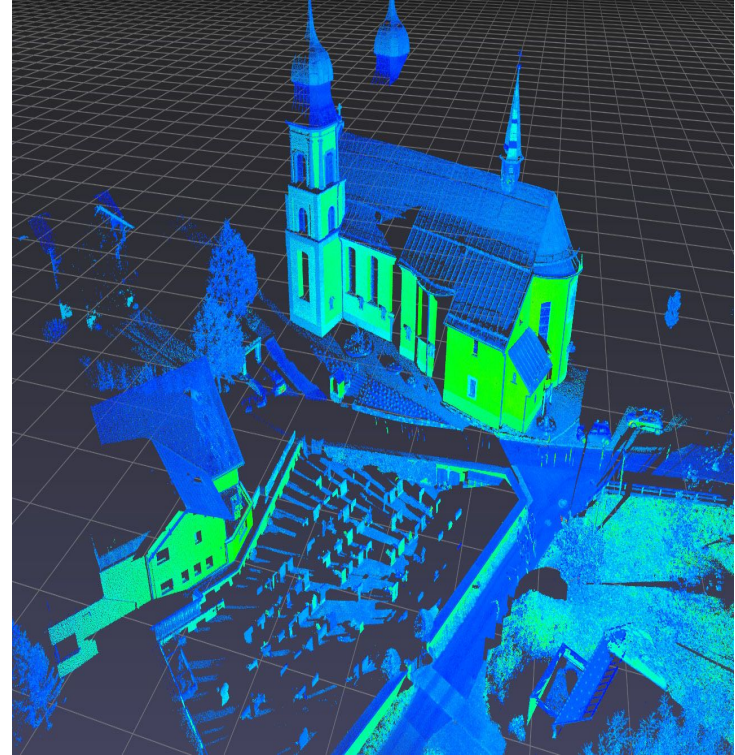
Loading the 3D point cloud dataset using Laspy

- The format of the point cloud dataset is .las
- We are using laspy python library to load the dataset.
- **Laspy** Python library allows reading, modifying and writing LAS files.
- Provides structure to use straightforward methods for X,Y,Z and RGB values.

```
def preparedata():  
    input_path="C:/Users/shubh/Desktop/"  
    dataname="2020_Drone_M"  
    point_cloud=lp.file.File(input_path+dataname+".las",mode="r")  
    points = np.vstack((point_cloud.x, point_cloud.y,point_cloud.z)).transpose()  
    colors = np.vstack((point_cloud.red, point_cloud.green,point_cloud.blue)).transpose()  
    normals = np.vstack((point_cloud.normalx,point_cloud.normaly,point_cloud.normalz)).transpose()  
    return point_cloud,points,colors,normals
```

Visualizing the Point cloud using PPTK

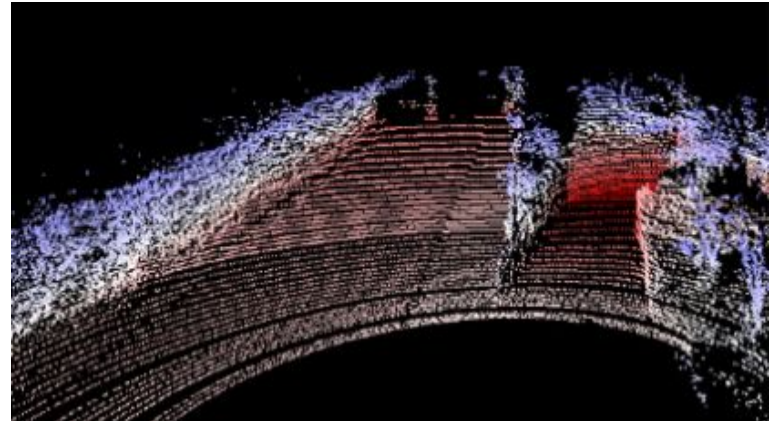
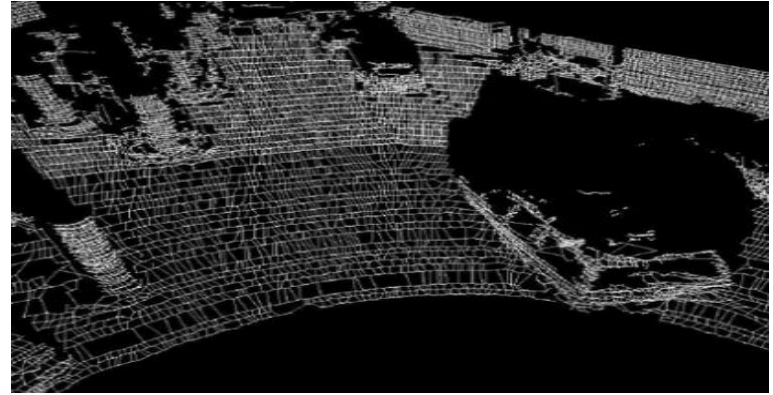
- Visualization of datasets helps avoid inconvenient I/O operations.
- PPTK Python library provides visualization capabilities for 2-D/3-D point clouds using point cloud viewer.
- Point cloud viewer **pptk.viewer()** accepts 3-column numpy array consisting of 3-D X,Y,Z values as input.
- It can render tens of millions of points using Octree level of detail generator mechanism.
- The key idea here is to cluster multiple vertices of the polygonal object created using the adjoining point that are close in object space.



Adding colors to the pptk cloud viewer

- The cloud viewer once organizes the input points into octree ,the octree approximates the groups of points reducing the number of points being rendered.
- But we miss colors in the visualization of the points.
- Colors are coded in 16 bits from the .las point cloud dataset.
- The values are needed to be in $[0,1]$ interval which is why we need to divide the colors variable containing RGB attributes of the points.

```
v.attributes(colors/65535)
```

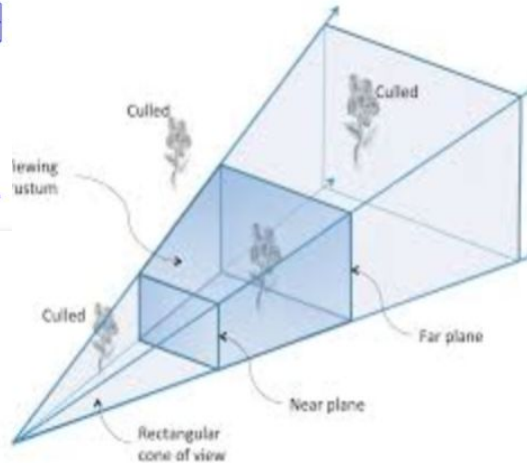
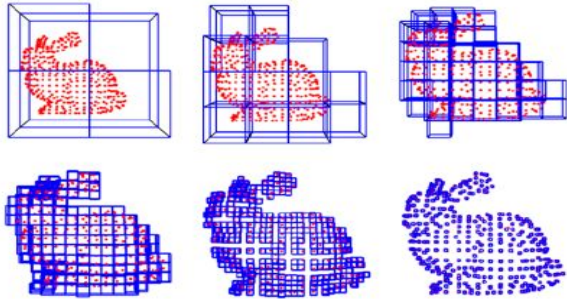


PPTK VS OPEN3D

The PPTK viewer organizes the input points into an octree.

As the 3D viewpoint is being manipulated, the viewer uses this octree to approximate groups of faraway points as single points and to cull points that are outside the view frustum, thus greatly reducing the number of points that need to be rendered.

Once the viewpoint is no longer being changed, the viewer then performs an exact rendering of all the point.



- Open3D is an open-source library with a set of carefully selected data structures and algorithms in both C++ and Python.
- Open3D was developed from a clean slate with a small and carefully considered set of dependencies.
- Open3D provides a function `draw.geometries()` for visualization.
- It takes a list of geometries as input, creates a window, and renders them simultaneously using OpenGL.
- Good for less than 50 million points in dataset
- Supported file formats:

xyz, xyzn, xyzrgb, pts, ply, pcd

Demo and Visualization

THANK YOU