THE UNIVERSITY OF BRITISH COLUMBIA

Building UBC in Minecraft

Transforming LiDAR Data into a Minecraft World Using Deep Learning and Geospatial Data Processing

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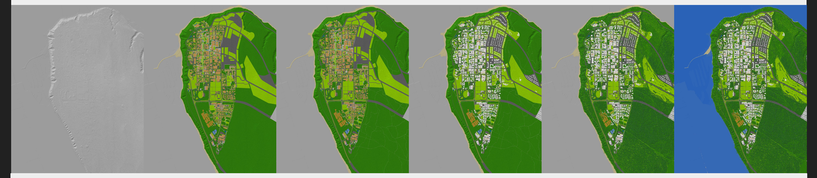
Motivation:

- To create an 1:1 **interactive digital twin** of the UBC campus
- Enhance realism beyond a naive voxelization through a multilayered data pipeline
- Train deep learning models to address inherent flaws in aerial LiDAR data
- Gain additional insights about the LiDAR data to make smarter block type selections



1. Rasterized DEM from LiDAR Data
2. Colorize DEM
3. Street Data Integration
4. Buildings (LiDAR-DenseSeg)
5. Shrubs + Trees (Forest Friends)
6. Place Ocean

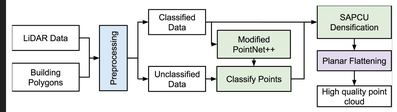
Deep Learning Pipelines

LiDAR-DenseSeg

Unclassified Data:
Large areas in some buildings are not classified properly or are left unclassified

Sparse Input Data:
Aerial LiDAR data sparsely captures points on wall faces

Quantization Errors:
Some points are truncated to a different voxel than their neighbours



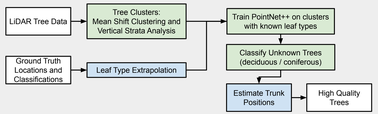
- Resolve unclassified data through training and applying a PointNet++ semantic segmentation model
- Resolve input data sparsity through self-supervised point cloud upsampling on building data
- Reduce quantization error through RANSAC-based nearest neighbour smoothing

Forest Friends

Lighting Challenges:
Shadows prevent accurate use of LiDAR color data in choosing leaf type

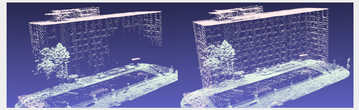
Missing Trunks:
Trunks are not captured through aerial LiDAR data, especially in dense forests

Crown Clusters:
Naive ML clustering segments trees with large crowns into multiple clusters

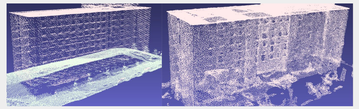


- Cluster individual trees using horizontal mean shift clustering, performing vertical strata analysis to re-assign crown clusters
- Choose consistent per-tree leaf type through biological family classification of individual tree clusters using PointNet++
- Estimate trunk positioning using cluster information, choosing wood type based on classification

Results of LiDAR-DenseSeg



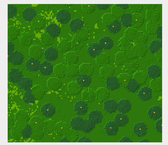
- 95.4% accuracy in semantic segmentation of building points
- Successfully fills in missing walls in areas missing classification
- creates a more complete building facade, enhancing downstream voxelization or mesh reconstruction tasks



- Densification addresses the inherent sparsity in the LiDAR data
- However, it amplifies errors in the semantic segmentation model, reducing voxelization quality

Results of Forest Friends

- 89.5% accuracy in classifying tree clusters
- Denoises tree models through removing unclustered points
- Resolves all issues in lighting challenges, missing trunks, and crown clusters



- Classification is dependent on clustering accuracy and spatial extent of clusters

Overall Results

- Successful production of a high-fidelity virtual twin of the UBC Campus
- Fully automated pipeline to transform LiDAR and open street data into a Minecraft world
- Visual accuracy in terrain generation, street data and flora to the extent Minecraft permits

Future Work

- Resolve lack of color in buildings through integration of additional data sources
- Shape atlas-based neural network for block type selection, 3D shape dithering, and noise reduction in building facades
- Floor estimation given a building facade and number of floors

Why?

Accurate surface reconstruction from aerial LiDAR scans is extremely useful:

- Game Asset Creation
- Aerospace and Defense
- Virtual Reality
- Urban Analysis
- Mapping and Visualization
- Forestry

Project GitHub:
github.com/ashtanmistal/minecraftUBC

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