AUTODESK UNIVERSITY

WF20432

Point Cloud Extraction for Infrastructure Projects

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Learning Objectives

- Learn how to use point cloud visualization for analysis
- Learn how to generate a terrain/surface from point cloud data
- Learn how to use point cloud information between InfraWorks and AutoCAD Civil
- Learn how to model infrastructure assets in InfraWorks using point clouds

Description

Point clouds are an important component in current infrastructure projects, and it is vital to know how to handle them for successful project execution. This class will provide all the necessary information to import, process, and extract information from point cloud data in Autodesk, Inc., architecture, engineering, and construction products. More specifically, this class will teach surface/terrain generation from high-resolution point cloud data in InfraWorks software, and it will demonstrate how to use it in AutoCAD Civil 3D software. The class will also cover how to model city asset features to create a virtual city model, and how to bring those city assets into a design product, such as AutoCAD Civil 3D software, as Coordinate Geometry (COGO) points. This class has no prerequisite. Any knowledge of InfraWorks software, AutoCAD Civil 3D software, and point clouds will be helpful in understanding the class material. At the end of this class, attendees will be able to use point cloud data with ease and confidence for their modeling and design projects. This session features InfraWorks 360 and AutoCAD Civil 3D.

Your AU Expert(s)

Kevin Grover is the regional technology lead and unmanned aircraft systems (UAS) operations manager at Stantec. His group has been collecting, processing, and extracting data from terrestrial and mobile laser scanning for the past 8 years, and with UAS for the past 3. With the amount of data collection technology being utilized at Stantec, Grover is always looking for better ways to capitalize on processing software to enhance and improve data extraction methods. He is leading the growth of UAS operations at Stantec for survey, mapping, and inspection purposes.

Ramesh Sridharan is a product owner in the AEC Product Development Group (PDG) at Autodesk, Inc. His team focuses on creating solutions that enable users to utilize reality-capture data for major infrastructure designs and models. To realize this goal, they work on 3D point-cloud processing, machine learning, and image processing that extracts and models core information content for large, reality-capture, point-cloud data that are used for modeling and design purposes. Before joining Autodesk, he was a chief technology officer at Virtual Geomatics, which was acquired by Autodesk in 2014. As a CTO, he was in charge of product development that focuses on point-cloud information extraction for different infrastructure applications. He has been working with the reality-capture field for more than decade and a half, and he received his postgraduate degree from Indian Institutes of Technology, with research focus on image processing and artificial intelligence.

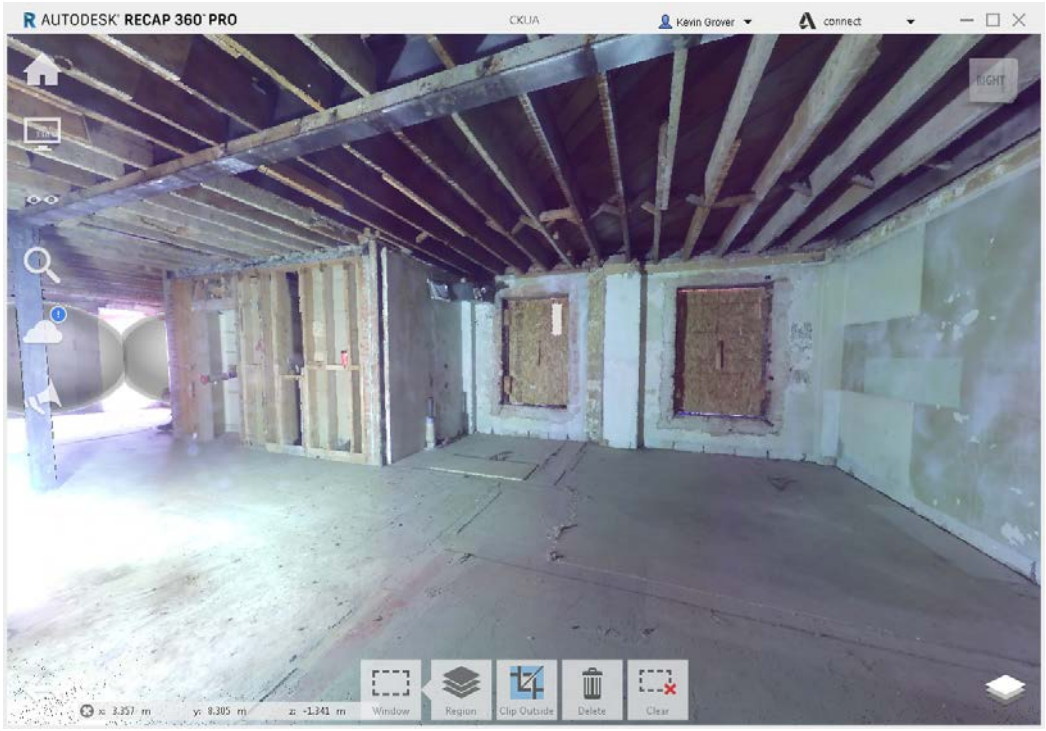
How to use point cloud visualization for analysis

Autodesk has advanced the ability to utilize point cloud information over the last several years. Using programs like Autodesk Recap, users can import large point cloud datasets with tools for managing, cropping and visualizing in an efficient way. This class won't focus on importing data into Recap, but assumes knowledge of import data into Recap is known.

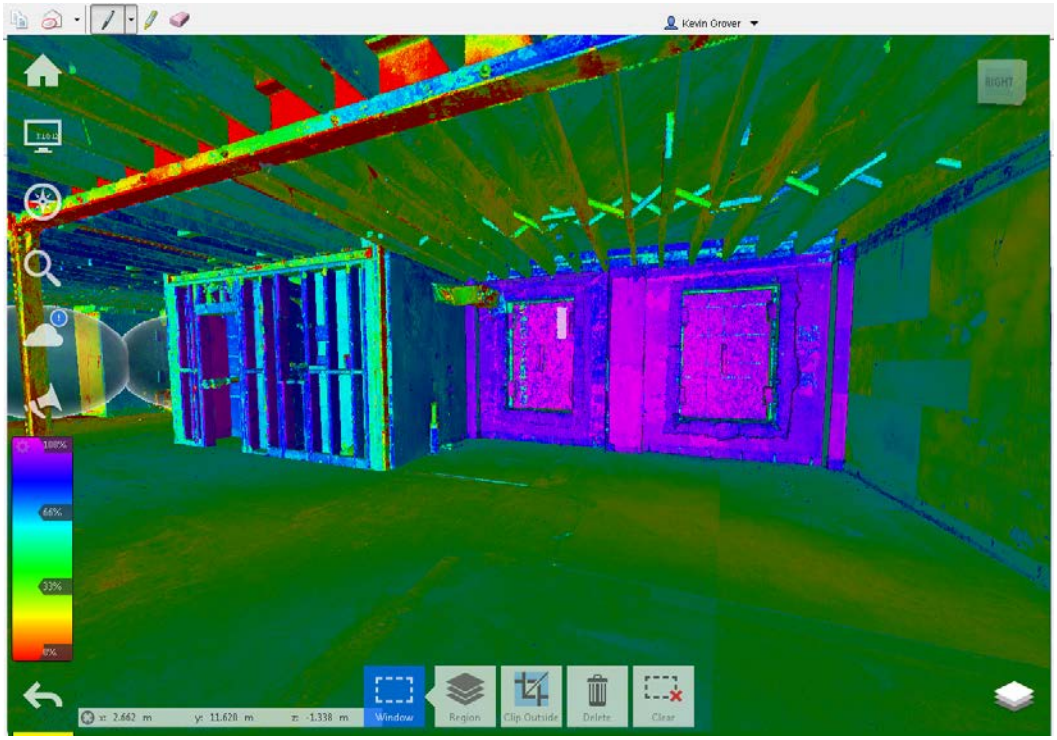
Autodesk Recap

Recap offers a wide range of visual styling options for the better viewing of point cloud data. Depending on how the data is collected will determine if all the visual styles are available.

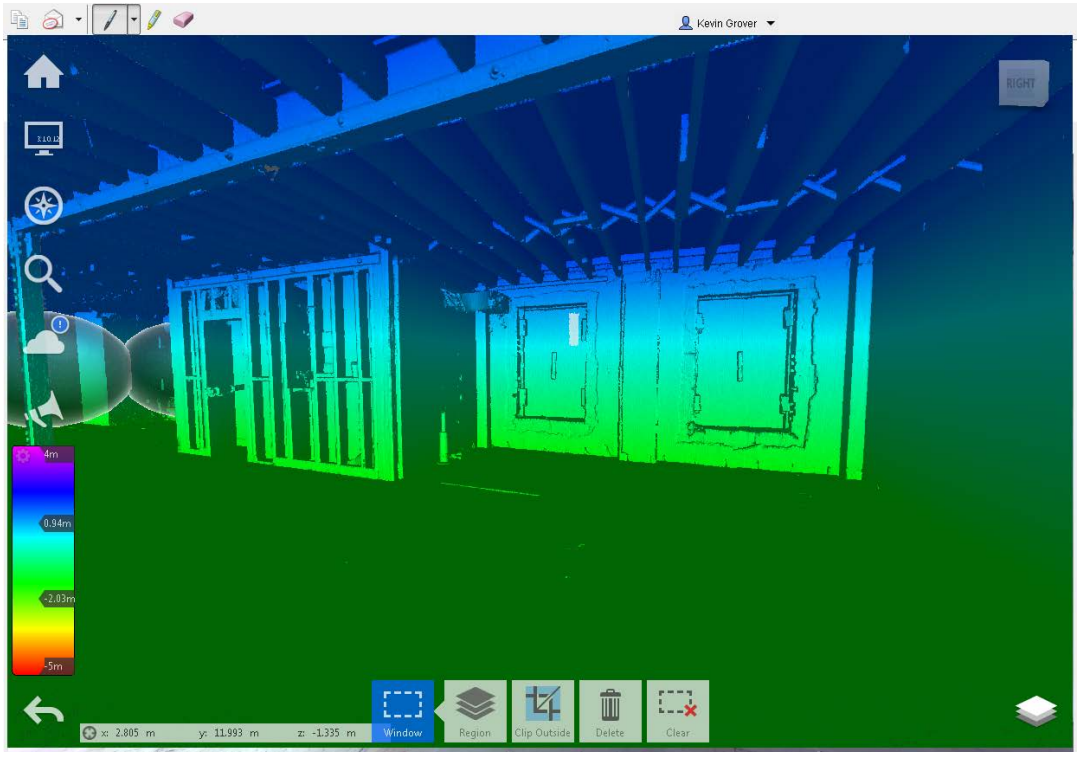
RGB - When a point cloud is collected along with high resolution imagery, Recap has the ability to assign a color index value to each 3D point. This visual style is ideal for the most realistic view of a point cloud.



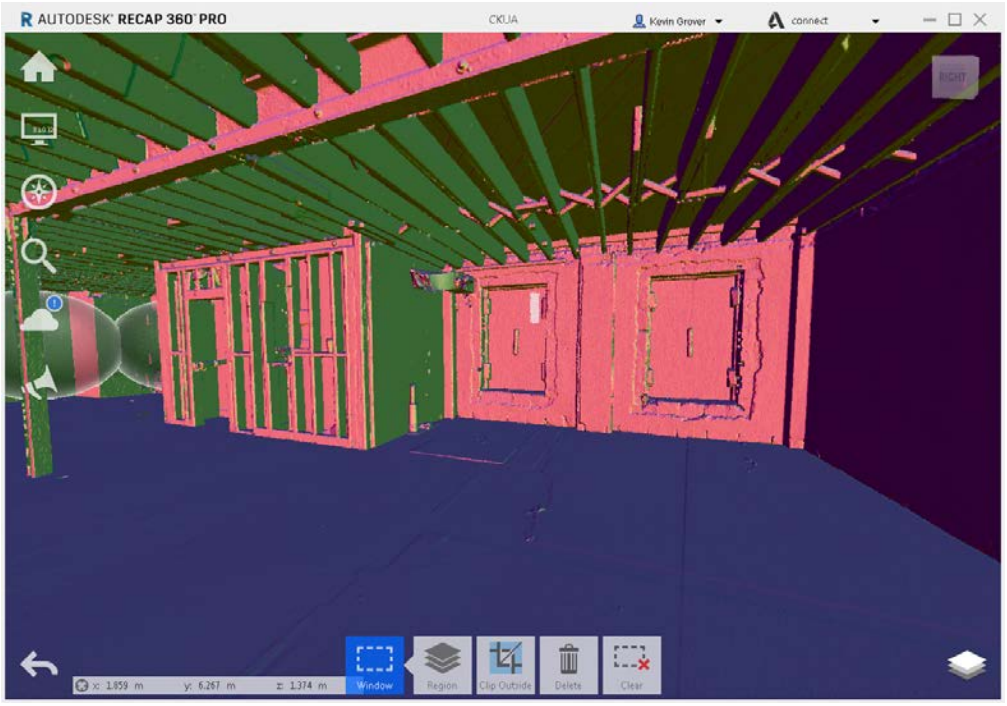
Intensity – Laser scanners have the ability to collect a reflectance value of each 3D point. This is the native viewing setting for points cloud when imagery is not collected.



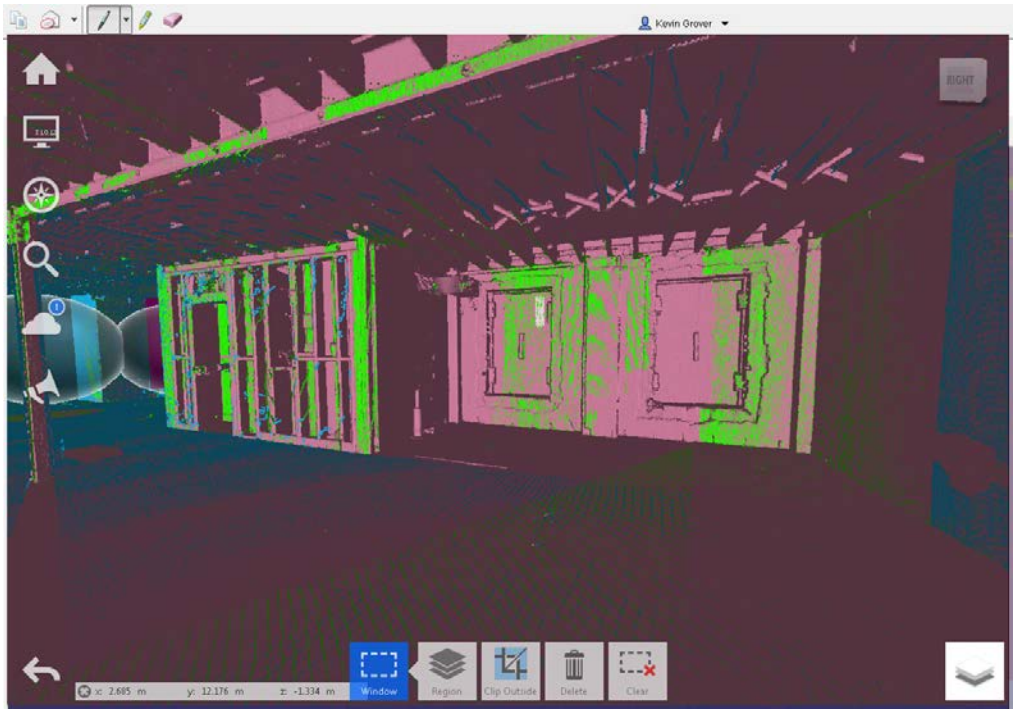
Elevation – As each 3D point has an elevation value, a point cloud can be viewed by a color elevation range. This visual style is ideal for surface topography.



Normals – During the preprocessing stage in Recap on import, normals are calculated to determine the planarity of surfaces and how surfaces relate to each other. This visual style is ideal for modeling in 3D to determine the relationship between surfaces.



Scan Location – For a dataset derived from terrestrial laser scanning, scans can be colored by scan location to determine data overlap. This isn't a commonly used visual setting.



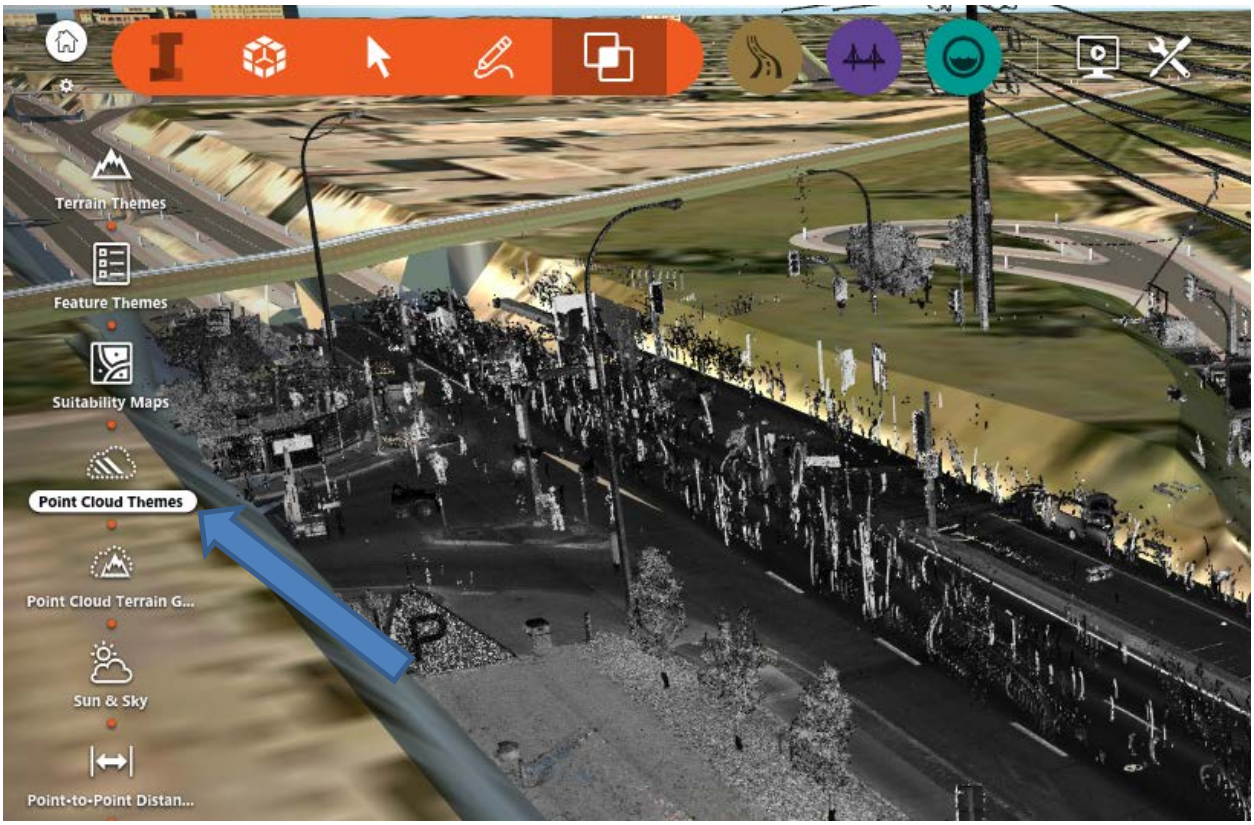
Autodesk Infraworks

Infraworks has been able to ingest point cloud data for the last few years, and the visual quality in the software has been advanced substantially. On first import of a point cloud, it will default to RGB if color imagery was collected, or given a black and white intensity view when RGB is not present.

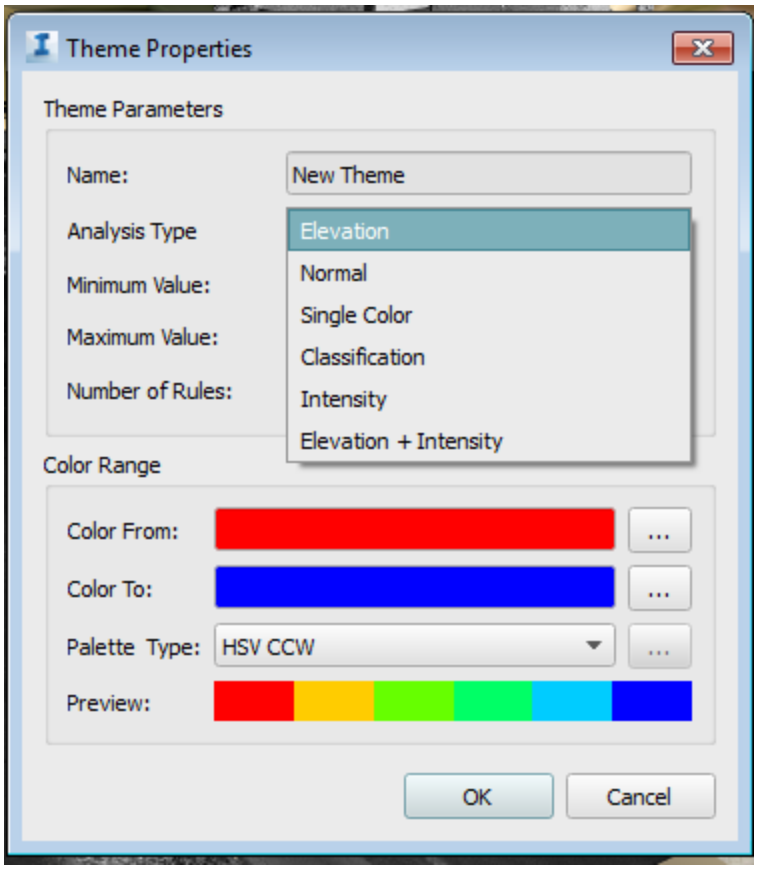
Importing - Point clouds can be imported similarly to any other data format in Infraworks, but it has to be in the Recap scan project format (RCP) before import. Once imported, the data can be assigned a coordinate system, scale, translation, etc.

Styling – Upon first import, RGB is the default style that is assigned in Infraworks. If color was not collected during the scan, then it is a black and white intensity view of the point cloud. Infraworks does have functionality to style a point cloud like Recap, however, these styles must be defined manually.

- Choose Point Cloud Themes



- Press the  icon to add a new theme
- Now you can customize by elevation, normal, single color, classification, intensity, or elevation and intensity



Usability of Point Cloud in Infraworks

Even though the ability to import a point cloud into Infraworks is possible, there are still limited tools to work with the point cloud.

- Primarily for visualization purposes
- Limited tools to manually work with point cloud
- No editing of point cloud in Infraworks

The automated extraction tools recently introduced will be discussed in the next section.

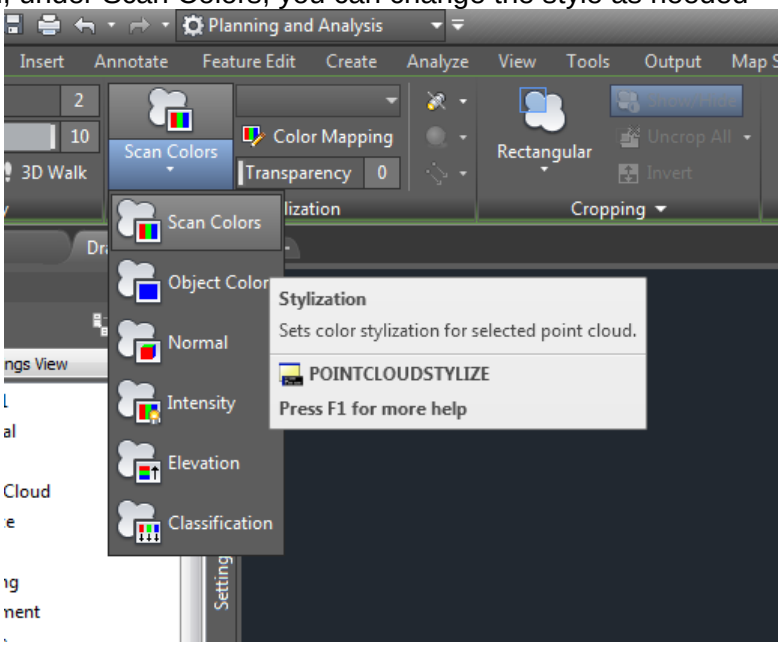
Items to consider with point cloud data in Infraworks:

- Requires disk space – on import of an RCP project, a copy of the entire point cloud data is placed in the Infraworks working directory structure. Ensure there is adequate local storage depending on the size of the point cloud file
- Unified data – this will enhance to performance of the point cloud in Infraworks. Ensure the scan locations are not needed for further functionality, as they are all merged into one large scan file.

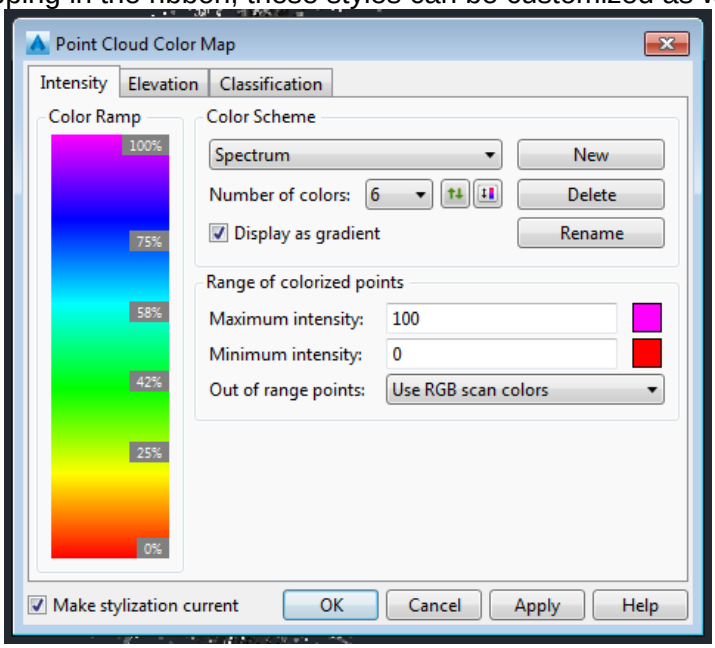
Autodesk Civil 3D

Similarly to Infraworks, a point cloud file can be imported into Civil3D. Once the point cloud is inserted into Civil3D it can be styled.

- Select the point cloud, and this will change to the point cloud ribbon
- Once selected, under Scan Colors, you can change the style as needed



- Under Color Mapping in the ribbon, these styles can be customized as well.



Tips for better performance of points clouds

- Unified data – this will enhance to performance of the point cloud in Infraworks. Ensure the scan locations are not needed for further functionality, as they are all merged into one large scan file.
- Split large datasets into multiple projects – tile datasets prior to importing
- Assign regions to the Recap project file

How to generate a surface from point cloud data

Point clouds are a great dataset for Infrastructure projects, however they can be challenging to work with efficiently. As these types of projects can be quite large, the point cloud files become even more difficult to handle due to the file sizes. The point cloud itself is considered non-intelligent (only a mess of 3D points), it is necessary to extract usable data from the point cloud for design purposes.

Depending on the level of information needed to extract (ie. Ground surface, curb and gutter, utilities, paint lines, etc.), this will determine how much time and effort is needed to do so. As there are many ways to do this, the next section will focus on various methods.

Manual Workflow

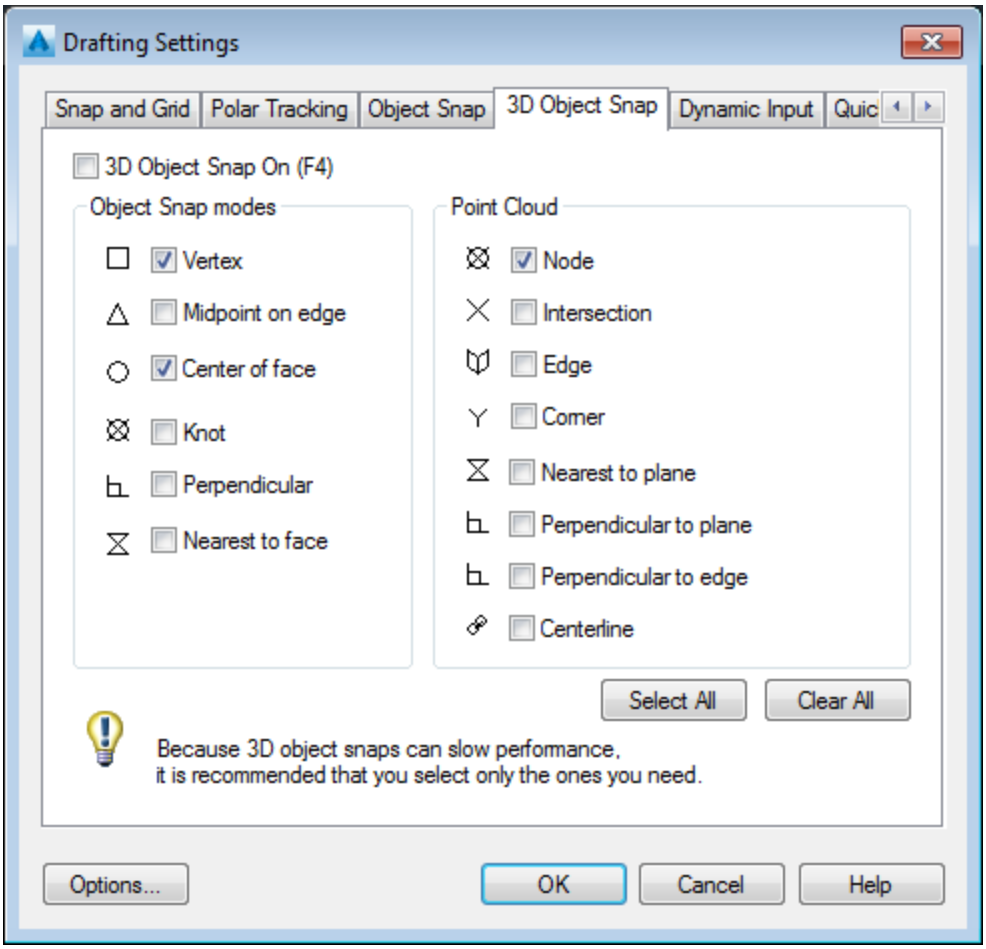
Typically, manual extraction of data from point clouds is done when limited information is needed from it for design. It is a time-consuming process to fully extract data manually, but is necessary on many occasions for certain features.

Manual extraction is typically best for the following:

- Utility extraction (manholes, valves, power poles, etc.)
- Trees (trunk location and drip line)
- Power lines
- Surface points (noisy / occluded areas)

Autodesk offers some basic tools for the manual extraction of features from point cloud data using the 3D Object Snaps for point cloud tools in Autocad. Autocad (and all verticals including C3D) has the following tools:

- Node
- Intersection
- Edge
- Corner
- Nearest to plane
- Perpendicular to plane
- Perpendicular to edge
- Centerline



Using these tools in Autocad products objects such as block, C3D points, or 3D linework can be manually placed using the point cloud.

Some challenges using these tools include:

- Incorrect snap locations
- Can't snap to center of object (ie. Power pole, tree trunk, etc.)
- Time consuming

Tips for manually placing features include:

- Crop the point cloud to view smaller areas of data
- Crop horizontal planes of the point cloud to aid in extraction building outlines and vertical features (power poles, trees, etc.)
- Change the visual style to intensity or normal view

Infraworks does not offer any tools to work manually work with point clouds, however, 3D objects can be manually placed using the point cloud.

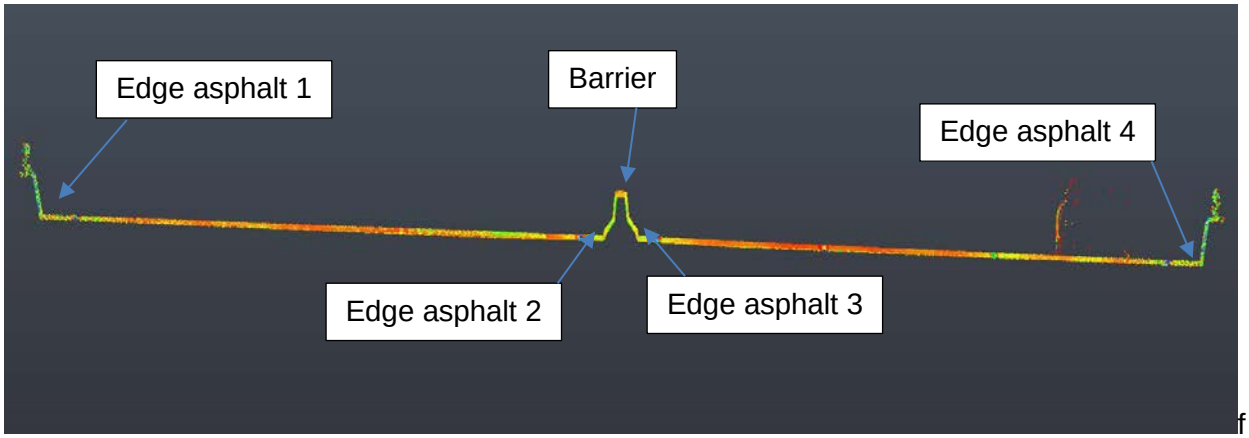
Semi-Automated Workflow

As manual extraction can be time consuming, using a semi-automated processing can be a preferred method for extracting features from point clouds. As a note, Autodesk does not offer these tools natively in the software, it is typically done through third party add on packages. These methods will only be discussed in general.

Cross Section Method

The cross-section method is typically the preferred method for linear corridor extraction from point clouds for curbs, road crowns, sidewalks, etc. The benefit of this method is that much faster extraction can be completed when similar features are needed. The process involves the following:

- Create an alignment along the corridor
- Create sections of point cloud along alignment at required interval
o Typically 0.3 meter (1 foot) width at 10 meter (30 feet) intervals
- Define point or linework codes for features to extract



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- Move to next station along alignment and define the same extraction points. Continue along alignment until each section is extracted

The benefits of using this method include:

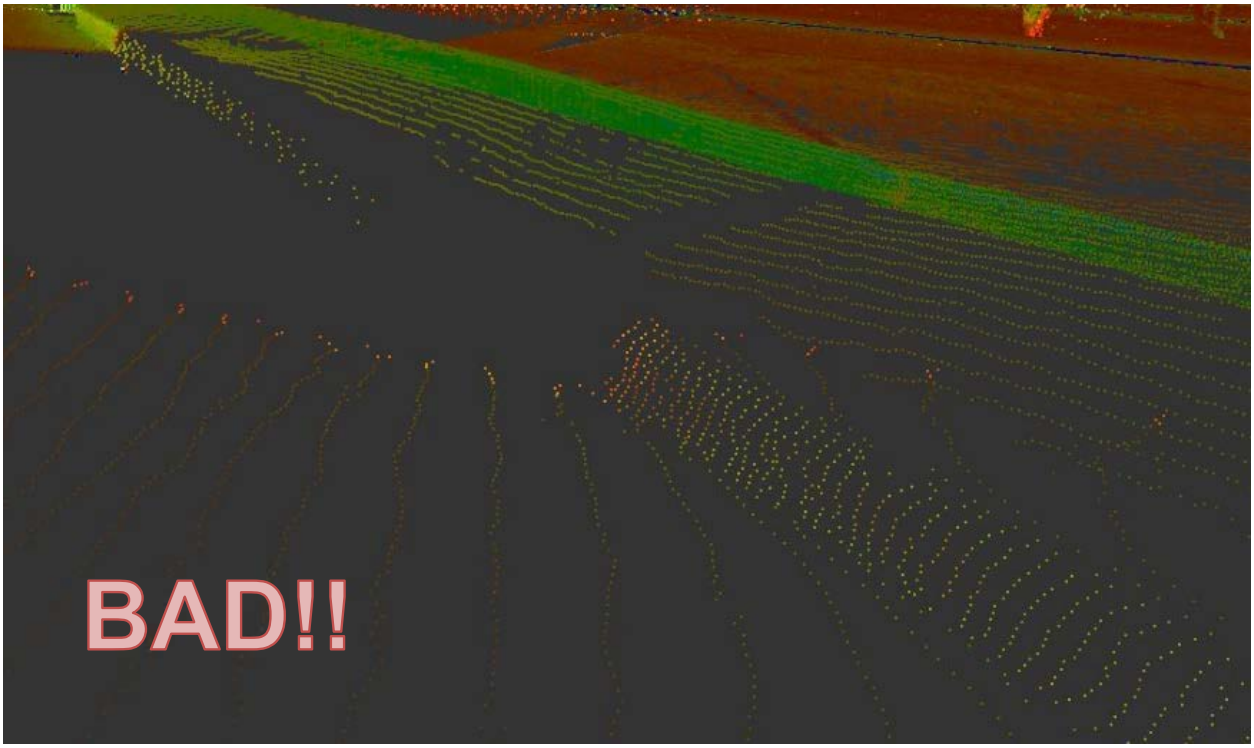
- Great for consistent corridor extraction of features
- Simplified method of extraction
- Generates 3D polylines (or survey figures / features lines)
o These 3D polylines can be used to create a simpler surface in C3D

Automated Workflow

This is the method of extraction that had increased development focus of late as end users of point cloud data are looking for the “easy button” solution.

This type of automated extraction is challenging for many reasons. It requires the following to be successful:

- Seamless point cloud datasets
  - Minimal occluded areas (lack of point cloud data)
  - Consistent density of data (not dense in areas and sparse in others)



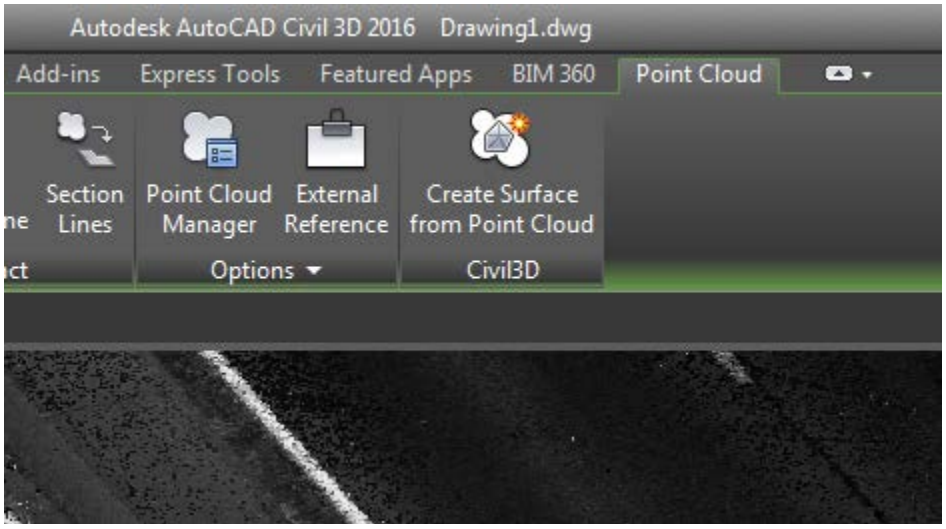
- Type of sensors used for collection. Point clouds datasets vary in accuracy (terrestrial, mobile, aerial, or photogrammetry), which can make it harder to extract various features.
    - Aerial Lidar – typically collected very high with less dense point cloud (5-20 points per sq. meter). Good for general topography but not for accurate extraction of defined features (ie. Curbs)
    - Mobile Lidar – more accurate that aerial, however does vary based on quality of system used, collection methodology, amount and quality of ground control points, and quality of vendor collecting. With a high quality dataset, this is the preferred method of data collection for infrastructure projects due to the consistently spaced data, but has challenges of line of sight.
    - Terrestrial – most commonly method of point cloud data, but does vary based on quality of system used, data registration methods (targeted vs. cloud to cloud), amount and quality of ground control points, and quality of vendor. With a high quality dataset, automated extraction can be successful but still has challenges with occluded areas, vegetation, and line of sight issues.
    - Photogrammetry – with the advancements and interest in drones recently, photogrammetric processing is allowing for more use of this data for infrastructure work. It is not the preferred method for collection due to regulatory hurdles (over people and roads, etc.) as well as heavy data processing requirements.

Civil 3D Surface Creation

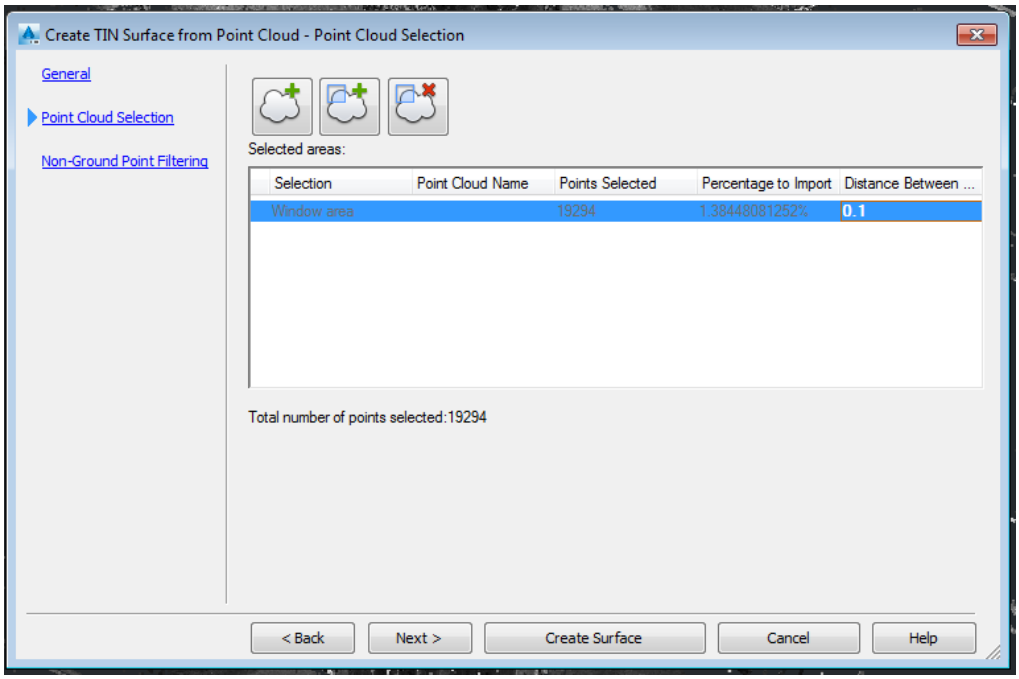
Civil3D has had tools for a while now to create a surface from a point cloud, including a way to filter a point cloud in order to derive a ground surface. The automation of this workflow can be successful for general terrain, but does struggle with accurately defining hard features (edges, curb, etc.).

The steps to create a surface from a point cloud are:

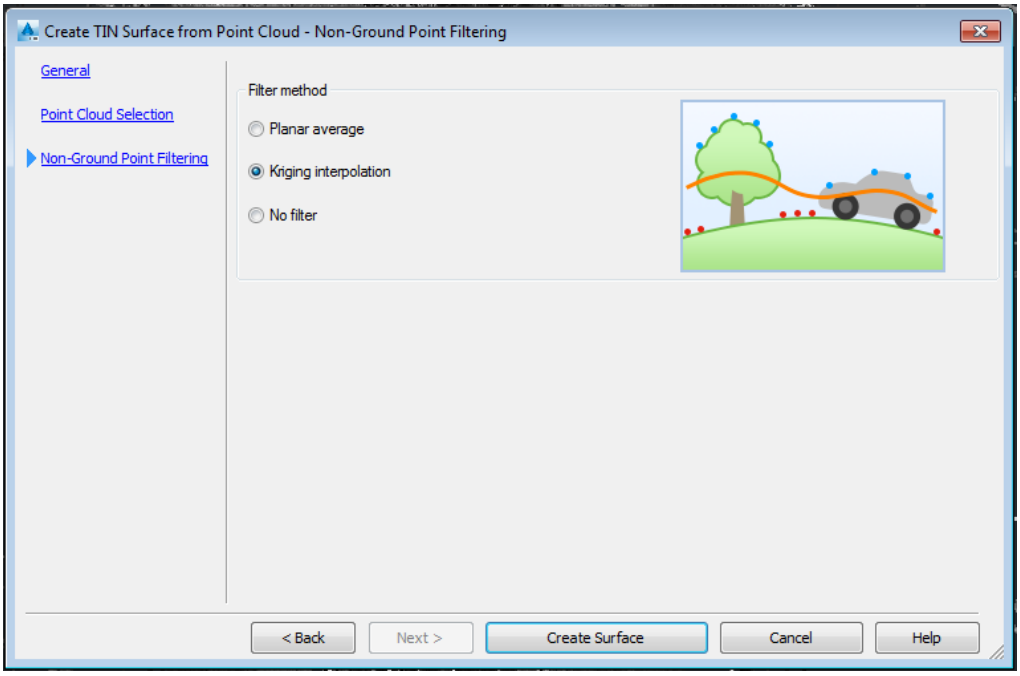
- Choose “create surface from point cloud”



- Name and choose the surface style to apply
- Select area to create surface
- Change density of point cloud for surface creation



- Choose noise filtering (best for a ground terrain model is Kriging)



The benefits of this workflow are that any user can create a 3D terrain surface directly from a point cloud.

The challenges with this workflow are:

- Lack of definition of hard edges (curbs, edges, etc.)
- Noisy surfaces. As the process relies on algorithms there will be areas with noise or spikes in the surface that will have to be manually edited.
- Heavy surfaces. As the surface is generated from a dense point cloud, the surface tends to be very dense on its own even with filtering and segmenting options chosen. This may slow down Civil3D when viewing in 3D or with certain surface visual styles (3D faces, dense contours, etc.)

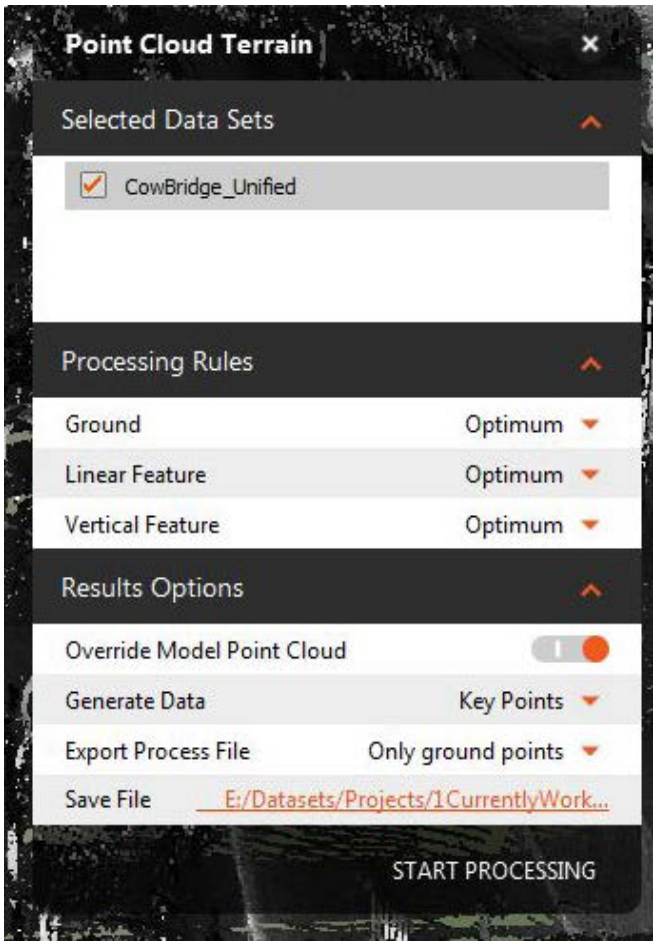
Infraworks Surface Creation

Autodesk has taken large strides in advancing the functionality of Infraworks, including the ability to classify and automatically extract features from point clouds. Infraworks is the ideal product for viewing point clouds as it is natively in 3D as are point clouds.

Here are the steps to work with point clouds in Infraworks:

- Once the point cloud data is imported and setup (map projection, scale, etc.), it is ready for the extraction workflow
- Choose the Point Cloud Terrain Generation tool

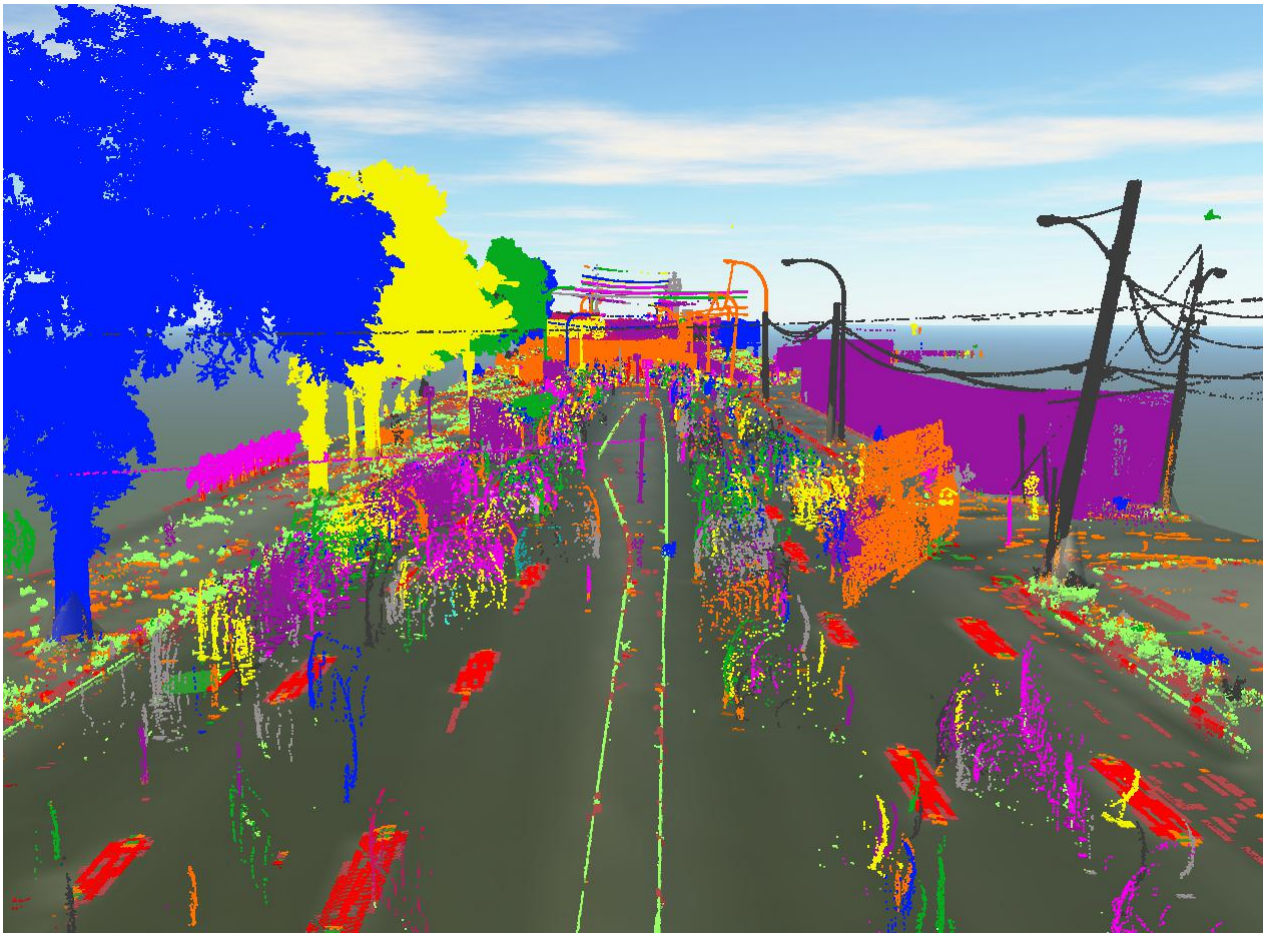
- This brings up the dialog with settings for extraction



- Settings can be customized as follows:
  - Selected datasets – can choose multiple point clouds if they exist
  - Processing Rules – Optimum setting is recommended
    - Ground – settings for “bare earth” ground surface extraction
    - Linear Feature – settings for linear features such as curbs and paint lines
    - Vertical Feature – setting for buildings, power poles, signs
  - Results Options
    - Override Model Point Cloud – as the point cloud file is being modified during this processing (filtered, classified, etc), there is the option to override the existing cloud with the edited one
    - Generate Data – option to generate a new point cloud file. All points, light weight, or key points.
    - Export Processed File – option to export the points to a new file. Options for all points, only ground points, or do not export.
    - Save File – set the save file location for the new point cloud
- Start Processing. This process can take some time depending on computer speed, so go grab a coffee!! Or a nap!

Once the processing is complete, at this stage, the point cloud has been classified to segment the dataset into common features. Under the Point Cloud Style options, one can set up a style for Classification in order to see how the data was processed.

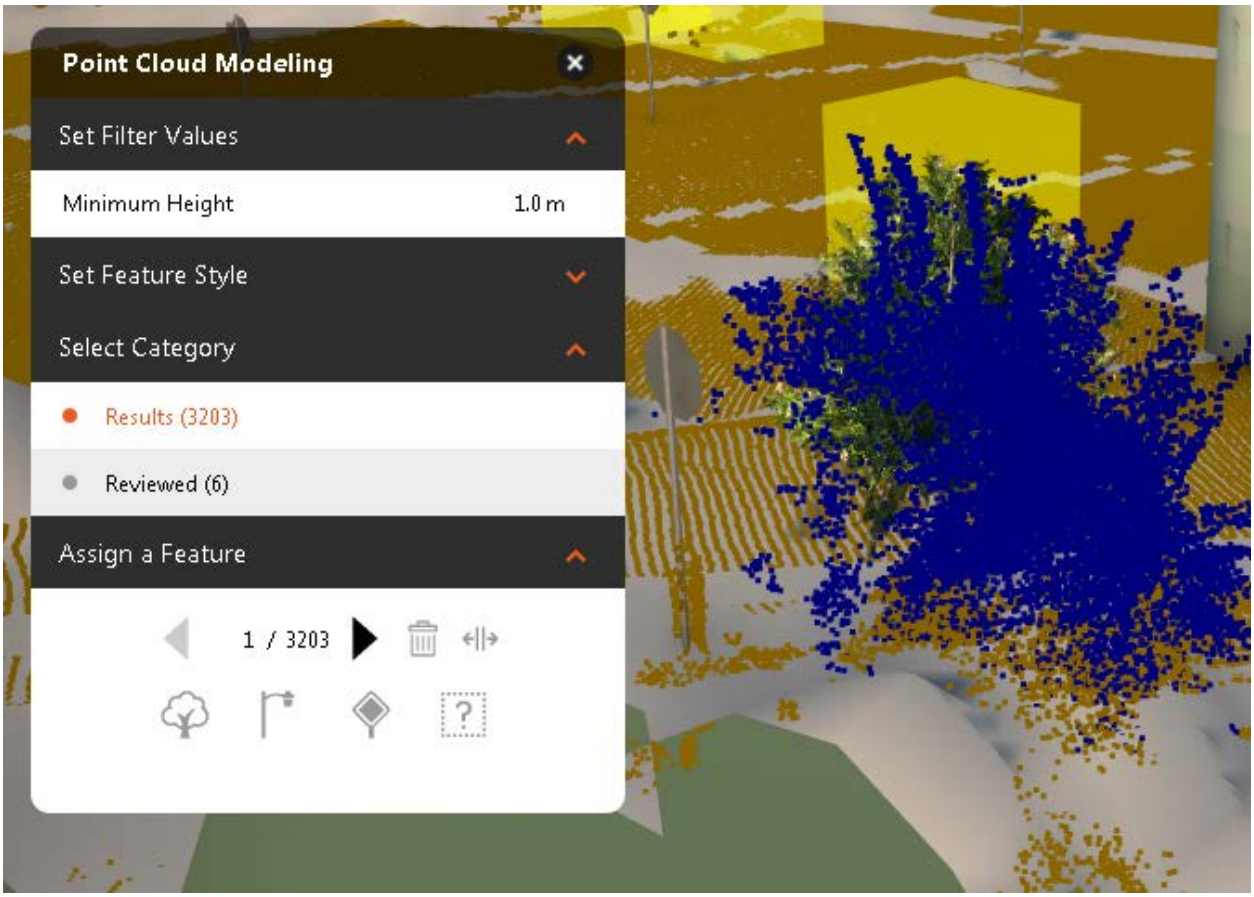
The coloring (as shown in the image below) is how the algorithms in Infraworks has been able to intelligently segment the data.



How to model infrastructure assets in InfraWorks using point clouds

After the point cloud has been classified, the next steps are to run the processes to intelligently interpret the data into usable features.

- Run the Point Cloud Modelling Tool
- Once extracted, a wizard interface is provided for further creation and editing of features
    - Adjust locations of detected features
    - Delete false positive features
    - Change type of feature



For a typical example, the images below show the progress from raw point cloud to extracted 3D features and a terrain model.

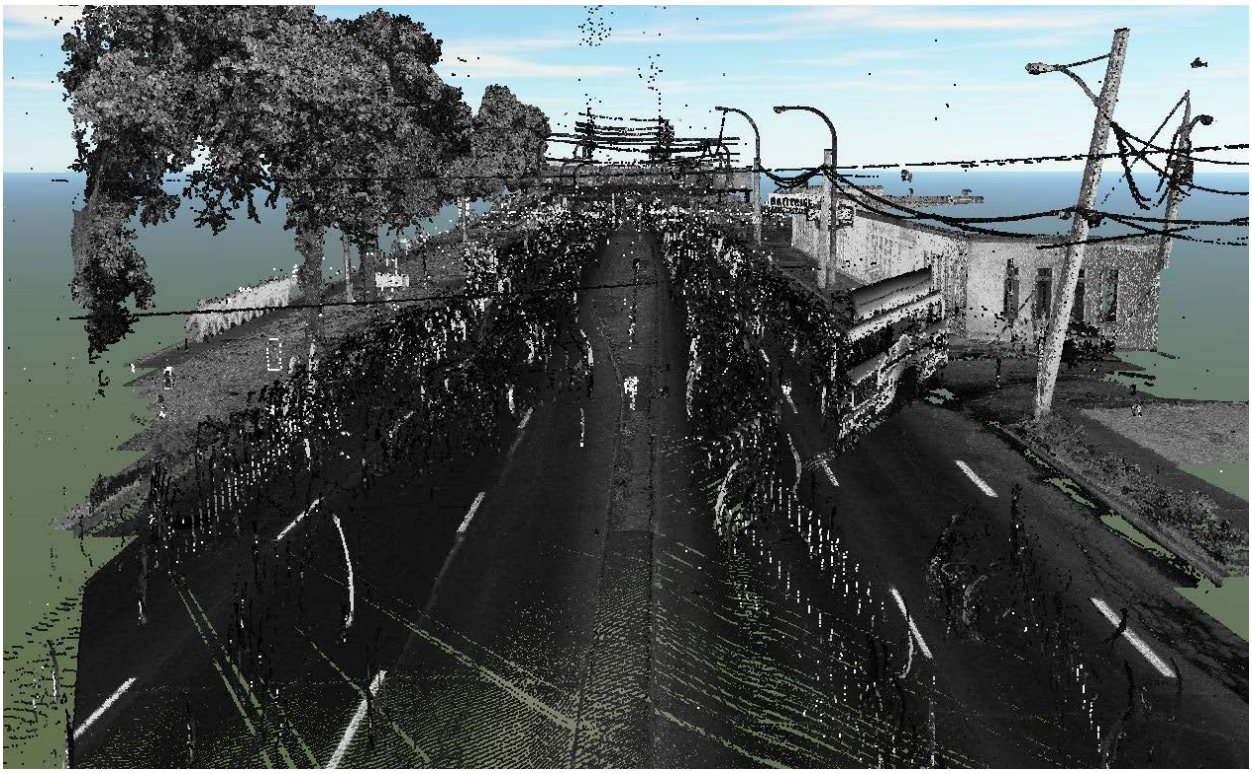


Figure 1 - Raw point cloud (intensity view)

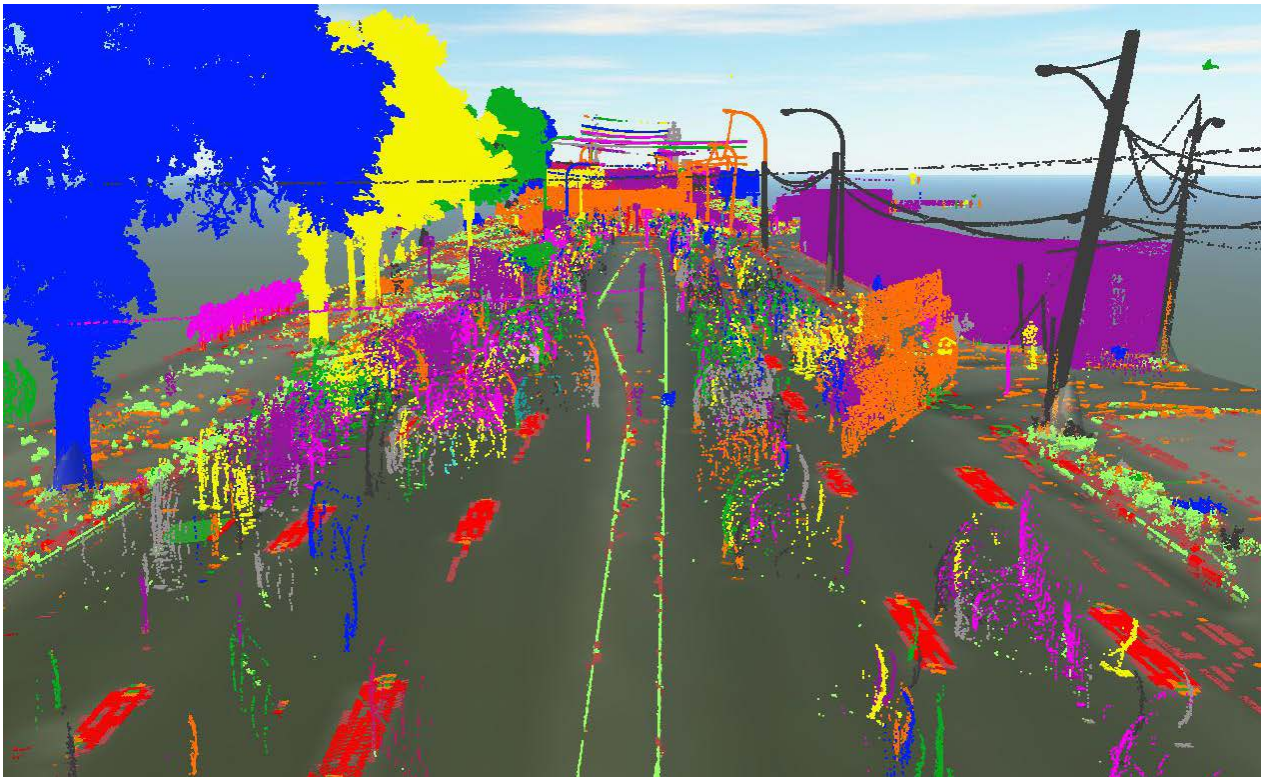


Figure 2 - Classified point cloud

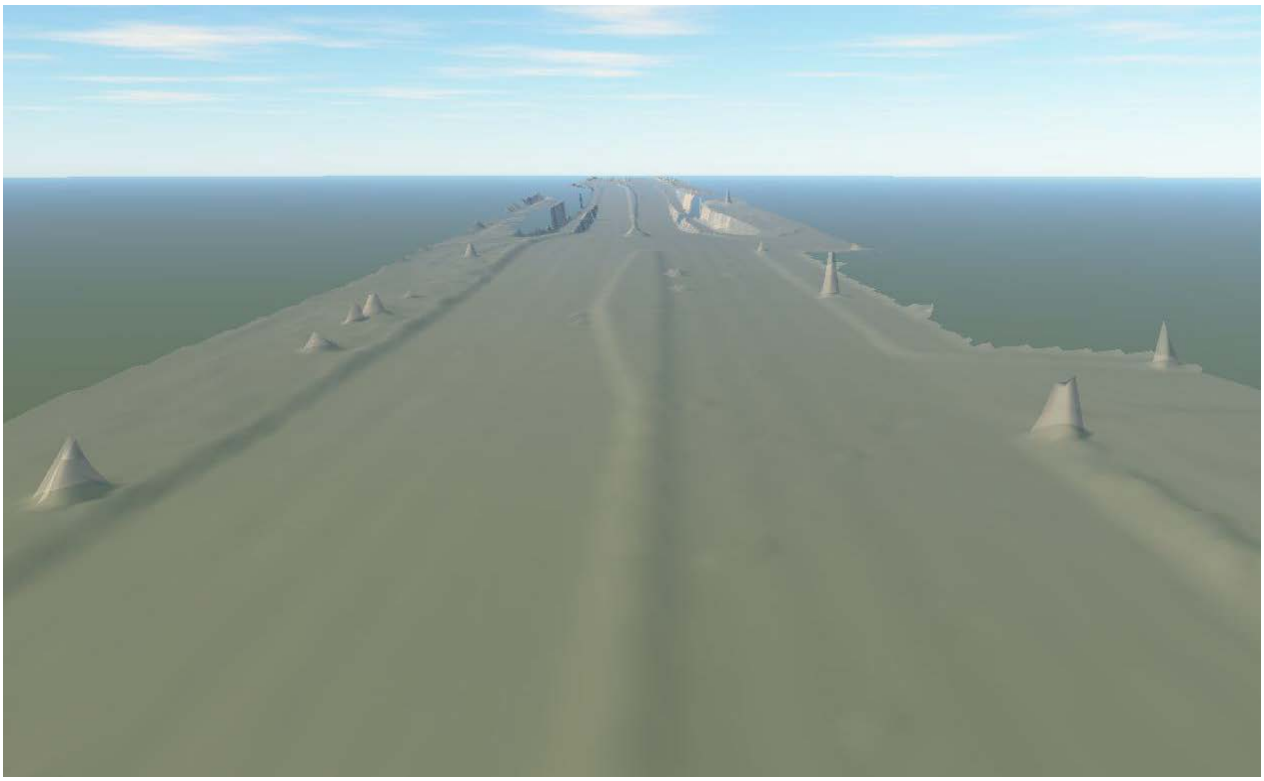


Figure 3 - Terrain surface

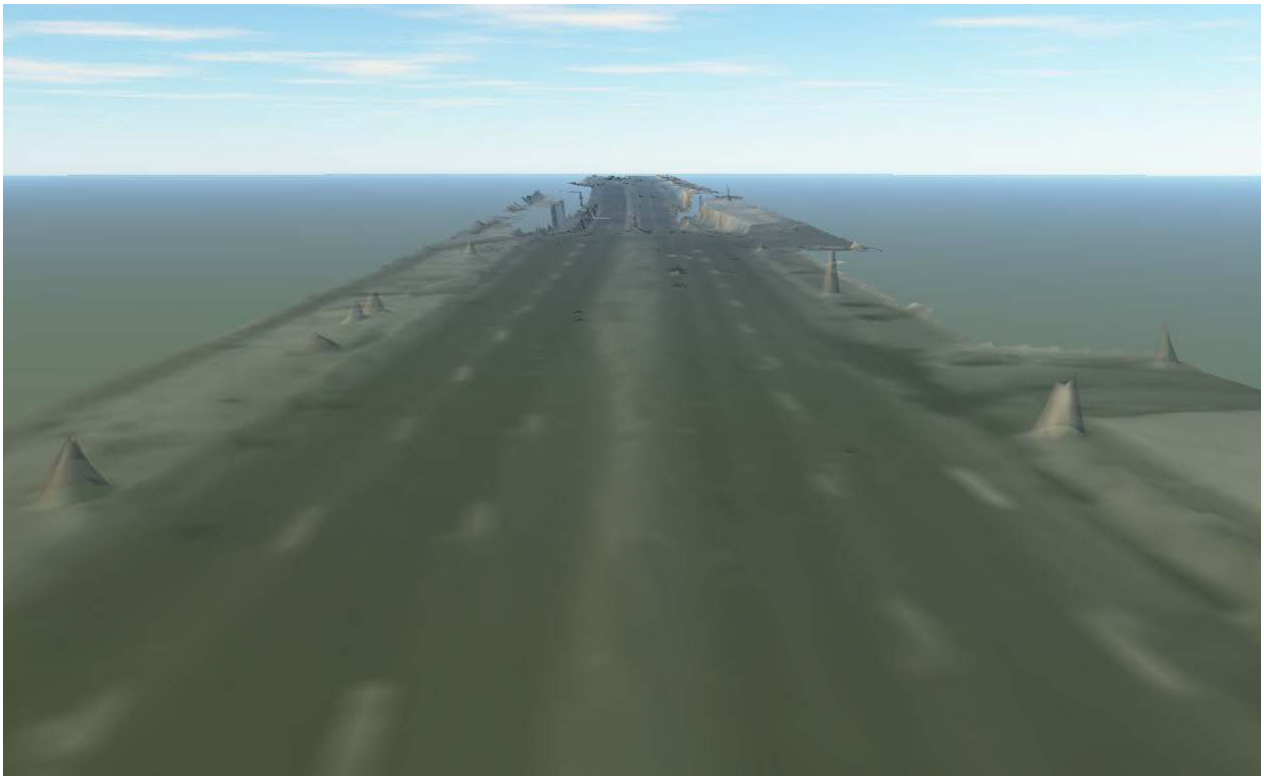


Figure 4 - Terrain with image overlay

Figure 5 - Terrain with 3D modeled features

Note: This last section will be edited for the course at AU, as there have been very recent enhancements that should be reflected.

Regards,

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