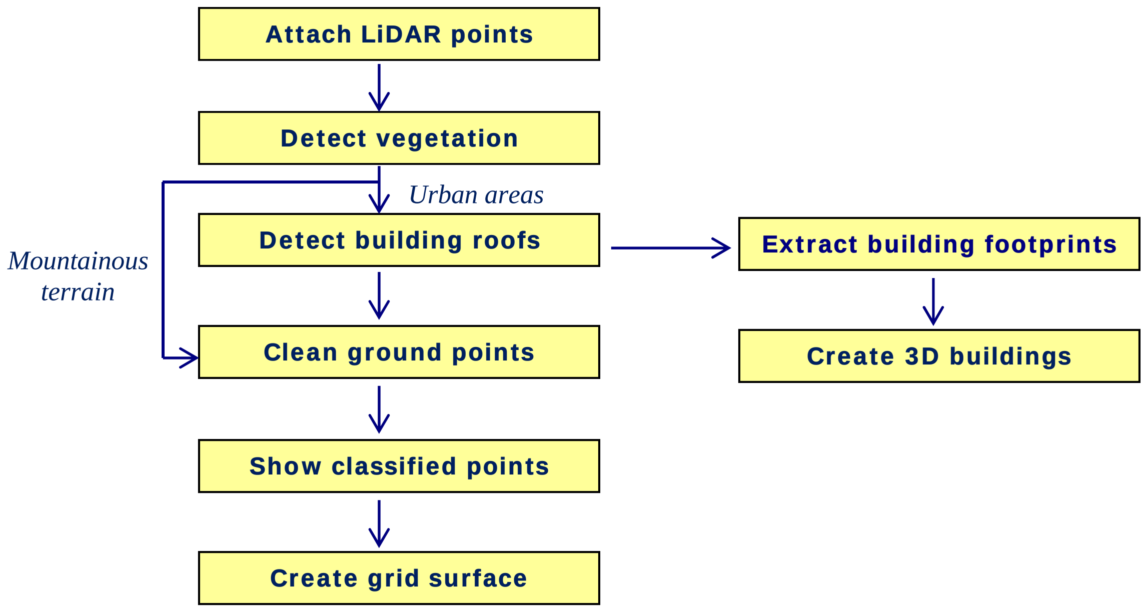
LiDAR Data Processing

Introduction

VRMesh provides a powerful point cloud classification and feature extraction solution for airborne and mobile LiDAR. It automatically extracts vegetation, buildings, and ground points from LiDAR data. 99% classification jobs can be automatically done in one click by setting a few simple parameters.

Unlike traditional LiDAR data processing workflows that have to extract ground points first before classifying vegetation and buildings, the workflow of point cloud classification in VRMesh is to detect vegetation first, then extract building roofs, and finally clean ground points. A basic LiDAR processing workflow in VRMesh is shown below:

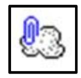


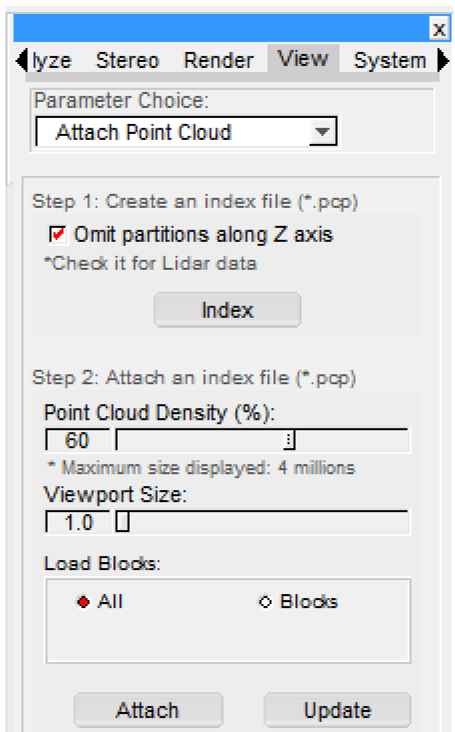
In addition, VRMesh supports batch processing of multiple files. It is recommended that using a sample file to figure out a customized workflow with tailored parameter settings. The batch mode will process all files in a specified folder one at a time using the same settings. Output results will be automatically saved to a subfolder at the same location as the original folder. The suggested procedure is:

1. Using the **Attach Large Point Cloud** command to retrieve inquiring points from a sample file into the window.
2. Using the **Detect Ground Points** command to classify visible points on the screen into vegetation, buildings, and ground. The purpose of this step is to figure out the appropriate parameter settings for your project.
3. Using the **Survey Wizard** to batch process multiple files in a selected folder.

Attach LiDAR Data

There are two commands that can be used to read a point cloud file (*.txt, *.asc, *.xyz, *.las, *.pts, *.dxf). The **Import** command imports all data into the window. The **Attach Large Point Cloud** command retrieves inquiring points into the window. Depending on your computer setting, you may choose to attach a point cloud file into the window if it contains more than 2 million points. The following instruction will guide you through the process.

Click the **Attach Large Point Cloud** command  from the File menu. The Index-Attach working panel appears in the Parameter Window on the right side of the screen, as shown below:



Step 1: Index

Press the [**Index**] button. A dialog box is opened to allow you to choose a name, directory, and file type for the file. The program will create an index file with a ***.PCP** extension saved to the same folder as the original file. Depending on the number of points in the file, it may take a few minutes to generate the index. Once the indexed PCP file has been created, you are ready to attach it into the window.

Step 2: Attach

Press the [**Attach**] button to attach the indexed PCP file into current project. The ***Point Cloud Density*** slider controls the number of points (density) displayed on the screen. Move the density slider to increase/decrease the amount of points and press the [**Update**] button to refresh the display. The maximum number of points that can be displayed on the screen is 4 million. The ***Load Blocks*** option allows you to specify which parts of blocks in the attached file will be loaded for processing. The program automatically divides data into different blocks when creating an index file. The total number of blocks in current file will be shown in the prompt window when you adjust the block range. The attached file appeared in the Object Tree Window will be marked with an asterisk, e.g., **Object*.

Note: You only need to create an indexed PCP file once for the same original file, which means that you can directly press the [Attach] button if the indexed file has already existed.

Bare Earth Extraction

The creation of a bare-earth surface involves classifying vegetation, buildings, and ground points in LiDAR data and then generating a grid surface or a triangulated surface to represent the topography. The following instruction will guide you through the bare-earth generation process.

Step 1: Detect Ground Points

Click the **Detect Ground Points** command in the Survey menu. A working panel appears in the Parameter Window on the right side of the screen. This is a composite command containing three steps for classifying point clouds:

1. **Detect Vegetation**

   This is the first fundamental step in VRMesh workflow for point cloud classification. You need to detect vegetation first, and then detect buildings, finally clean ground points. The program calculates roughness on point clouds to identify vegetation in LiDAR data. Normally, the value of roughness is set to 0.22 for an urban area, and 0.6~0.8 for a mountainous terrain. The value of minimum points required for a valid region is normally 5~50.

2. **Detect Building Roofs**

   This step automatically detects building roofs in point clouds, which requires that you have detected vegetation before. The maximum value of roof slope is normally set to 50~85. You also need to define the minimum height of a roof and the minimum / maximum number of points required in a roof.

   You may ignore this step if your data is from a mountainous region without buildings.

3. **Clean Ground Points**

   This step automatically deletes floating parts to get well classified ground points. There are two clean types. The ***Flat Region*** type is preferred to a flat urban region. The ***Steep Region*** type is preferred to a steep mountainous region. Both methods are working well for point clouds derived from airborne, mobile, terrestrial LiDAR, or from stereo imagery.

The composite command can be executed step-by-step or by one-click batch processing. Meanwhile, you may select the “***Only visible points***” checkbox to classify visible points on the screen only, which can be used to figure out the appropriate parameter settings for your project.

After the three steps, the ground points will be successfully identified. You may use the **Show Points by Classification** command in the Analyze menu to view each class of points. If the classification result has some errors, you may use the **Add Point to Ground** command to reclassify points within a certain distance to the ground class.

Step 2: Create a Bare-Earth Surface

There are two ways to generate a bare-earth surface in VRMesh. You may directly create a grid surface to represent the bare earth, which is simple and fast. Or, you may choose to interpolate points to ground and triangulate ground points to a meshed model, which is more accurate to represent the bare-earth topography.

For creating a grid surface, click the **Create Grid Surface** command in the Survey menu. Specifying the cell size and sampling method to create a grid surface from the visible points on the screen. You can use the **Show Points by Classification** command in the Analyze menu to control which class of points are shown on the screen. Please note that a grid surface generated using this command may not accurately represent the topography of a steep mountain. It's better to create a meshed surface for steep terrain.

For creating a meshed bare-earth surface, you need to use the **Interpolate Points to Ground** command in the Survey menu to finish the interpolation. Then, use the **Remove Redundant Points** command in the Cloud menu to reduce the size of the point cloud. You may also use the **Denoise Point Cloud** command in the Cloud menu to smooth the point cloud. Finally, use the **Point Cloud to Mesh** command in the Cloud menu to convert the point cloud into a triangle-meshed surface.

Building Footprint Extraction

VRMesh provides an automatic solution for extracting building footprints from LiDAR data and generating 3D building models. It doesn't require a good bare earth before identifying building roofs in VRMesh workflow. Therefore, VRMesh can successfully extract building footprints from areas where there is very few ground points available. The following instruction will guide you through the footprint extraction process.

Step 1: Detect Vegetation

Click the **Detect Vegetation** command in the Survey menu. Specify the parameter settings. Normally, the value of roughness is set to 0.22 for an urban area, and 0.6~0.8 for a mountainous terrain. The value of minimum points required for a valid region is normally 5~50.

Step 2: Detect Building Roofs

Click the **Detect Building Roofs** command in the Survey menu. The maximum value of roof slope is normally set to 50~85. You also need to define the minimum height of a roof and the minimum/maximum number of points required in a roof.

Step 3 (*Optional*): Clean Ground Points

Click the **Clean Ground Points** command in the Survey menu. The command automatically deletes floating parts to get well classified ground points. There are two clean types. The ***Flat Region*** type is preferred to a flat urban region. The ***Steep Region*** type is preferred to a steep mountainous region.

*Note: You may use the composite command **Detect Ground Points** in the Survey menu to finish the above three steps in one click.*

Step 4: Extract Building Footprints

Once you get the classified building roofs, click the **Extract Building Footprints** command in the Survey menu. Specify the number of points in each grid cell, normally 8 ~25, which is used to create a grid surface for footprint extraction. Define a minimum area for a valid roof. Additionally, there are two options for squaring up a footprint. If ***All Polygons*** is selected, the program will refine all corners to 90 degree. If ***Quadrilaterals*** is selected, the program will only refine the corners of quadrilateral shaped polygons to 90 degree.

Step 5: Create 3D Buildings

The program can automatically create 3D building models based on the building footprints. You may select the ***Create Buildings*** checkbox in parameter settings of the **Extract Building Footprints** command, or click the **Create Building from Footprint** command in the Survey menu. You can define a roof shape as an ***Approximate*** type, or a ***Flat*** type. The approximate type means the roof shape is close to the actual shape. The flat type means all roof shapes are horizontal. You may also specify the maximum number of triangles to represent a roof.

Step 6: Export

You can export building footprints or 3D building models to a ShapeFile or a DXF file.

Powerline Processing

Learn the general procedure for processing powerline data in VRMesh:

- Classify points into vegetation, buildings, and ground.
- Reclassify high points hit on wires by absolute elevation or the height from ground.
- Manually place catenary strings between towers.
- Detect powerlines along catenary strings.
- Analyze clearance using a tunnel object.

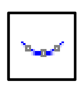
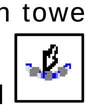
Step 1: Classify Point Clouds

Click the **Detect Ground Points** command  in the Survey menu. A working panel appears in the Parameter Window on the right side of the screen. The composite command automatically detects vegetation, building roofs, and ground points in LiDAR data.

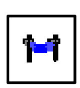
Step 2 *(Optional)*: Reclassify High Points

Those high points hit on wires or towers may have been classified into the building class in step 1. If it is clear enough for placing a catenary curve along those points between towers, you can ignore this step and go directly to step 3. If it is necessary to reclassify high points, you may use the **Absolute Elevation** command or the **Height from Ground** command in the Survey menu to get more accurate results.

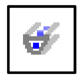
Step 3: Place Catenary Strings

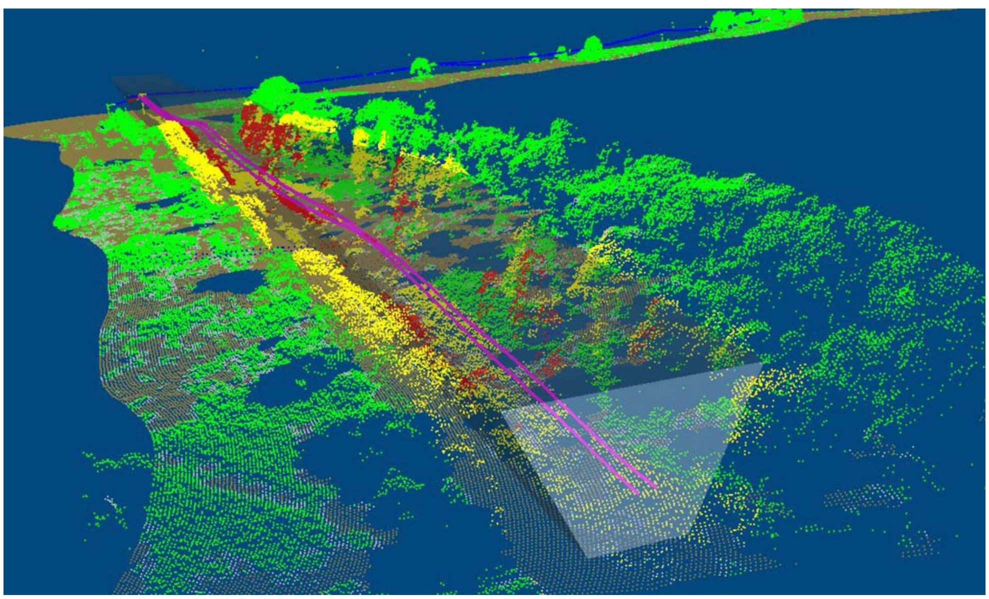
Click the **Place Catenary String** command  in the Survey menu. The cursor changes to a pencil. Click or drag mouse to sketch a curve along points between towers. Double-click to end the curve. You may use the **Adjust Catenary String** command  in the Survey menu to further adjust the curve.

Step 4: Detect Powerlines

The **Detect Powerlines** command  in the Survey menu will automatically classify points that form a selected catenary curve. You need to specify a source class and a target class. Define a maximum offset distance from catenary curve to search for points, which is normally set to a little bit more than half of the width of the powerline. Define a search gap between consecutive hits on a wire. It is recommended that you first try a relative short search gap for the detection. If the ***Apply to All Curves*** option is selected, the program will execute the command on all catenary curves.

Step 5: Analyze Clearance

The **Classify by Tunnel** command  in the Survey menu allows you to classify points based on the shape of a tunnel, which can be used to conduct a clearance analysis between powerlines and surrounding vegetation. The program will use a tunnel section template to classify points which are inside the tunnel, outside the tunnel or close to the tunnel section. You need to select a catenary curve to represent the centroid of a tunnel before using this command. If the ***Apply to All Curves*** option is selected, the program will execute the command on all catenary curves. In addition, the visibility and transparency of the tunnel object can be adjusted using the right-mouse menu in the Object Tree Window.



Point Cloud Classification

Learn how to automatically and manually classify LIDAR point clouds.

- Use automatic classification tool to classify points into different categories.
- Use manual classification tools to adjust wrong classifications in a cross section view.
- Visualize points according to elevation values and class visibilities.
- Export classified points to a LAS file.

Step 1: Automatic Classification

VRMesh provides intelligent solutions for automatic point cloud classification. Irregularly distributed LIDAR point clouds can be efficiently classified into different categories: *vegetation (low, medium, high), buildings, ground and others*.

The suggested steps are:

1. **Locate a testing region**

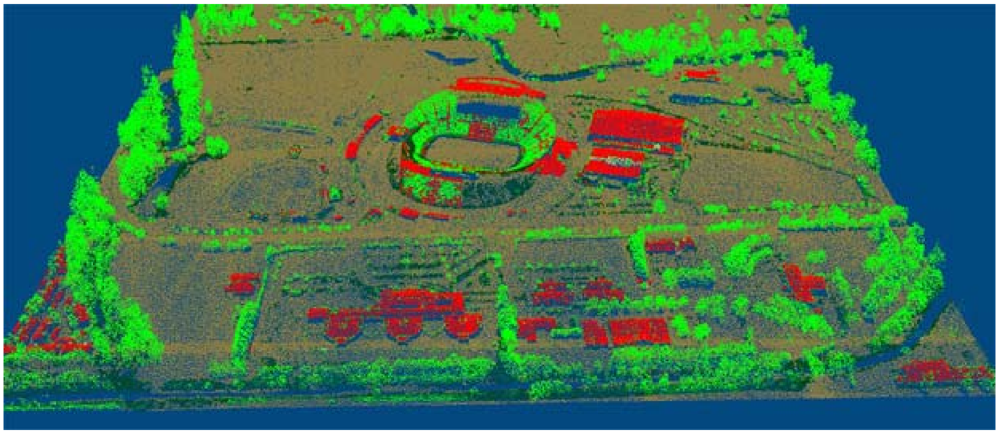
   Click the **Show Points by Elevation** command (*Analyze>Show Points by Elevation*), or click the icon  in the Toolbar. Adjust the maximum or minimum value to update the color mapping on the surface. Find a testing region and zoom in to only display this part of point clouds on the screen.

2. **Classify visible data**

   Click the **Detect Ground Points** command (*Survey>Detect Ground Points*), or click the icon  in the Toolbar. A working panel appears in the Parameter Window on the right side of the screen. Select the ***Only visible points*** checkbox. The composite command automatically detects vegetation, building roofs, and ground points in LiDAR data. Please note that, for better test results, you may need to let all points contained in the testing region be shown on the screen, which is controlled by the ***Point Cloud Density*** slider in the Index-Attach panel (*File > Attach Large Point Cloud*).

3. **Classify whole data**

   Once the parameter settings have been tailored for your project, continue the **Detect Ground Points** command, and uncheck the ***Only visible points*** box. Click the [Batch Process] button to classify the whole data set.

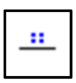


Step 2: Manual Adjustment

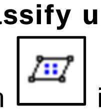
After automatic classification, you may need to adjust some wrong classified points. VRMesh Survey provides several manual classification tools to reclassify those points. You can classify points on the fly in a cross section view or directly in the drawing window.

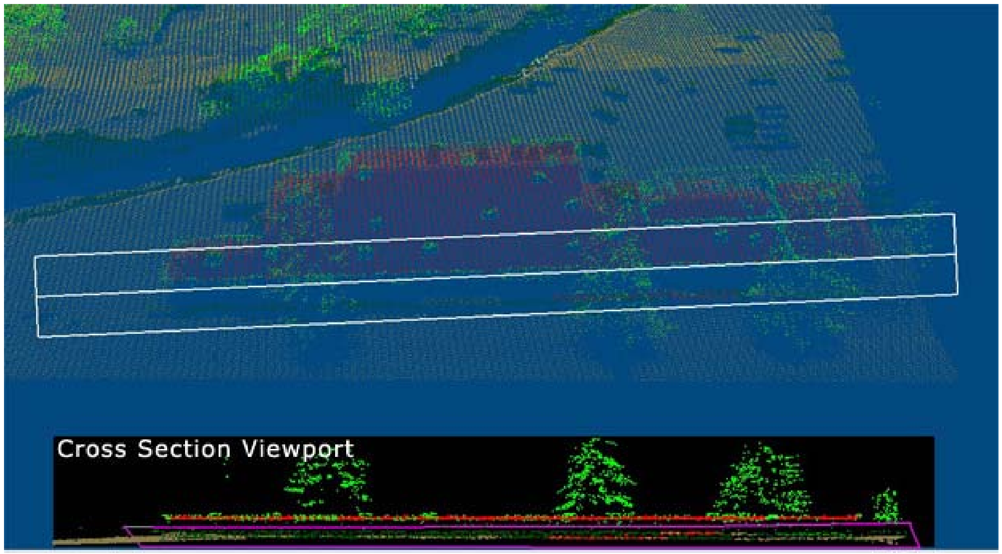
The manual classification tools include:

1. **Classify using line**

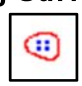
   Click the **Classify using Line** command (*Survey > Classify using Line*), or click the icon  in the Toolbar. A widget will be shown in the drawing window. Move/Resize the widget to define the cross line width and section view depth. Double-click on the widget in the drawing window to create cross section profile, which is shown in the cross section viewport on the bottom. Then, select ***From class*** and ***To class*** for each type which you want to reclassify. Move the lines in the cross section viewport to identify points. Double-click between the lines in the cross section viewport to start the classification. The model shown on the screen will immediately reflect the changes.

2. **Classify using polyline**

   Click the **Classify using Polyline** command (*Survey > Classify using Polyline*), or click the icon  in the Toolbar. A widget will be shown in the drawing window. Move/Resize the widget to define the cross line width and section view depth. Double-click on the widget in the drawing window to create cross section profile, which is shown in the cross section viewport on the bottom. Then, select ***From class*** and ***To class*** for each type which you want to reclassify. Click the [**Draw Polyline**] button in the parameter window. The cursor changes to a pencil. Draw a polyline to surround the desired points and double-click to start the classification. This tool allows you to classify target points accurately.



3. **Classify using surface curve**

   Click the **Classify using Surface Curve** command (*Survey > Classify using Surface Curve*), or click the icon  in the Toolbar. The cursor changes to a pencil. You can classify target points by drawing a curve to surround the desired region in the drawing window.

You also can use the **Classify using Brush** command (*Survey > Classify using Brush*) to classify points inside a brushing path. Meanwhile, you can define a new name for one of the ASPRS reserved class items using the **Define New Class** command (*Survey > Define New Class*).

Step 3: Point Cloud Visualization

Point cloud can be visualized using different color-mapping schemes based on elevation values and/or class visibilities.

1. **Show points by classification**

   Click the **Show Points by Classification** command (*Analyze > Show Points by Classification*), or click the icon  in the Toolbar. A class list is shown in the parameter window. You can assign a RGB color to one point class by clicking on the color square to choose a color. You also can control the visibility of each point class.

2. **Show points by elevation**

   Click the **Show Points by Elevation** command (*Analyze > Show Points by Elevation*), or click the icon  in the Toolbar. The elevation values of LIDAR points along the Z-axis will be shown using the color mapping on the surface. If the ***Combine Class Visibility*** checkbox is selected, the color-mapping scheme will consider both elevation values and class visibilities. For example, if you uncheck the visibility of vegetation class in the class list panel (*Analyze > Show Points by Classification*), those vegetation points will be assigned the lowest elevation value in the elevation color mapping. This option is useful for locating wrong classifications.

Step 4: Export Classified Points

You can export the classified points into a LAS file. Please note that, to export an indexed file, you should select the **Convert Indexed PCP File to (*.txt, *.las)** option in the File of Type box. This option allows you to export the whole point cloud data in the indexed file to TXT or LAS format. If you directly select the *.txt or *.las option in the File of Type box, only the amount of points displayed on the screen will be exported.