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Autodesk Feature Extraction

Getting Started with Point Cloud Feature
Extraction for Autodesk Revit 2012

Autodesk

1/19/2012

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1 Introduction

Point Cloud Feature Extraction for Autodesk® Revit® allows you to work with point cloud more easily in Autodesk® Revit®. This plug-in automatically extracts useful geometry features from point cloud of buildings and creates basic Revit elements to aid the building modeling in Revit.

This plug-in provides the following tools to facilitate the point cloud editing after it is inserted into Revit:

- **Crop / Uncrop:** Temporarily hide points outside a rectangle or polygon;
- **Hide Point Cloud:** Temporarily hide the whole point cloud object to facilitate the inspection of the feature extraction result;
- **Adjust Axis:** Transform the point cloud data so that floor is aligned with XY plane and major walls are parallel to Z axis;

Moreover, this plug-in includes some main features specifically for Revit as following so that the extracted features / geometry can be used for further Revit element generation:

- **Datum Extraction:** including extraction of both level and grid;
- **Site Extraction:** Extract both terrain surface for ground surface creation and building footprint on terrain surface for building pad generation;
- **Wall Extraction:** Extract both straight wall layout and arc wall;
- **Floor Extraction:** Extract floor from selected points on the floor plan level;

1.1 System and Environment Requirements

Operating Systems:

- Microsoft® Windows® XP With Service Pack 3 or higher
- 32-bit or 64-bit systems

Recommended CPU:

- Intel®Core™2Duo

Memory:

- 4 GB RAM

Hard Disk:

- 1 GB free hard drive

Autodesk Revit

- Autodesk Revit 2012

** All features have been tested on Revit 2012 with SP1 and Revit 2012 with SP2.*

2 User Interface

2.1 Feature Extraction Tab

The tools for point cloud feature extraction are located in Feature Extraction tab on the ribbon.

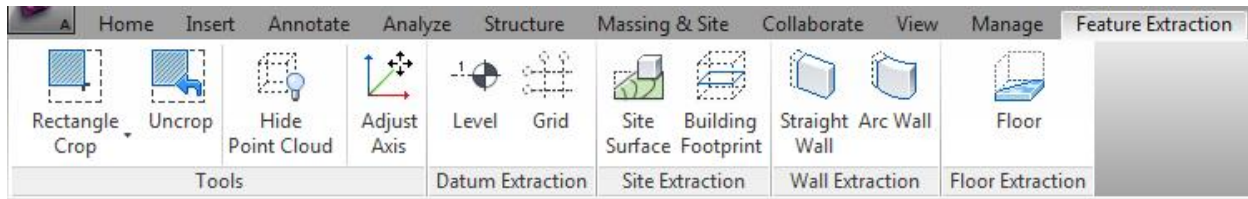




Figure 1: Feature Extraction ribbon in Revit


3 Tools


3.1 Crop Point Cloud


Scanner data may contain some data that are inadvertently scanned. Or when the point cloud data are the scan of a large scene, it is difficult for user to interpret the point cloud data.

-  **Rectangle Crop** will help user to temporarily hide points outside a rectangle.

-  **Polygon Crop** will help user to temporarily hide points outside a convex polygon;

 **NOTES:** Actually only the points located in the intersection area of the lines of the polygon will be shown; therefore, if user specifies a concave polygon, the result might be different as expected;

-  **Uncrop** will display all points. The cropping tools can work on multiple Point Cloud objects.

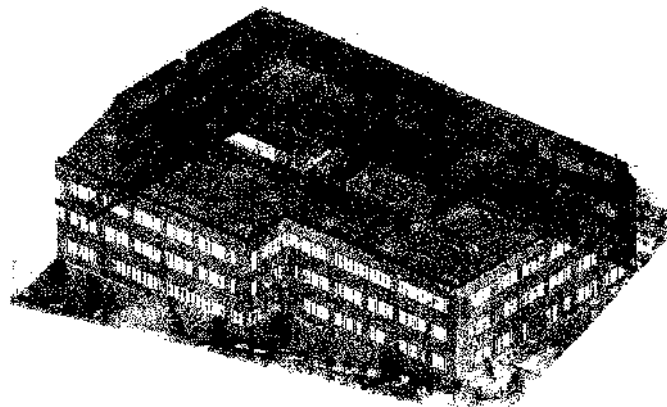
 **NOTES:** User cannot undo crop operation; if user wants to undo the crop result, he/she should use 'Uncrop' tool.



(a) The original point cloud



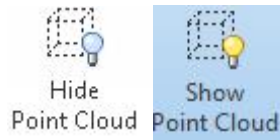
(b) Crop the point cloud with a rectangle region



(c) Points inside the crop region

Figure 2 : Point cloud crop tool

3.2 Hide Point Cloud

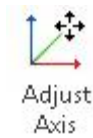


These two tools can control the temporarily hide or show the whole point cloud object to facilitate the observation of the feature extraction result.

3.3 Adjust Axis

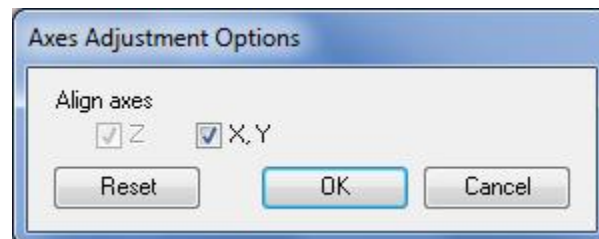
For most of the feature extraction tools we provided, there is an assumption that the floor of the point cloud is perpendicular to Z Axis. This tool is used to help the user to adjust the coordinate system of the principal axes of the point cloud if the point cloud has not been adjusted well before inserting into Revit.

3.3.1 Workflow



1. Select Adjust Axis tool.
2. Select points as reference for principal axis estimation.
3. Set the option for axis adjustment;
4. The tool will estimate the principal axes (X/Y/Z) and automatically rotate the point cloud object to the new coordinate system so that the floor is on XY plane and the main wall components are aligned with X/Y axis;

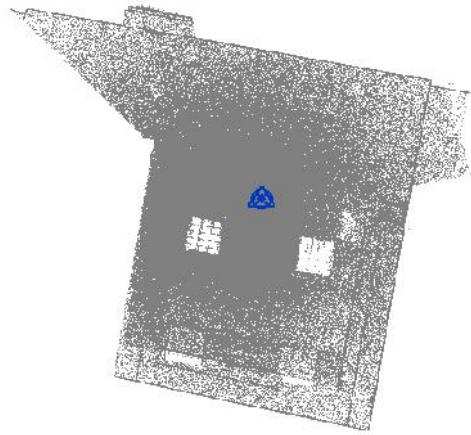
3.3.2 Parameter Setting



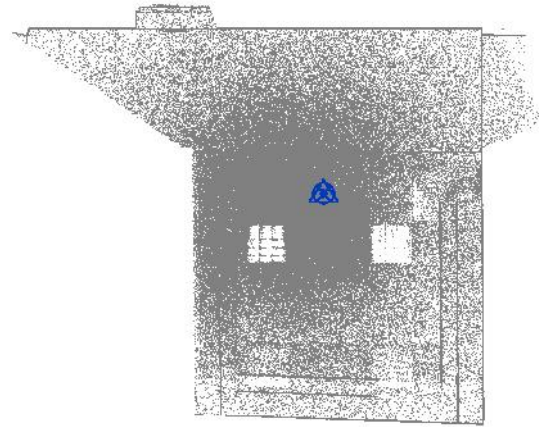
If user only wants to adjust the Z axis, then the 'X,Y' checkbox should be unchecked; In this case, the point cloud shown in Figure 3(a) won't be rotated; otherwise, all of X/Y/Z axis will be adjusted, as shown in Figure 4(b).



NOTES: This is an automatic tool to aid the user to adjust the point cloud; while in some cases, the algorithm cannot distinguish the order of the axes, i.e., the estimated X axis is actually Y axis of the world coordinate system; in this case, user needs to manually rotate the point cloud to adjust the order of the axes;



(a) Before principal axis adjustment



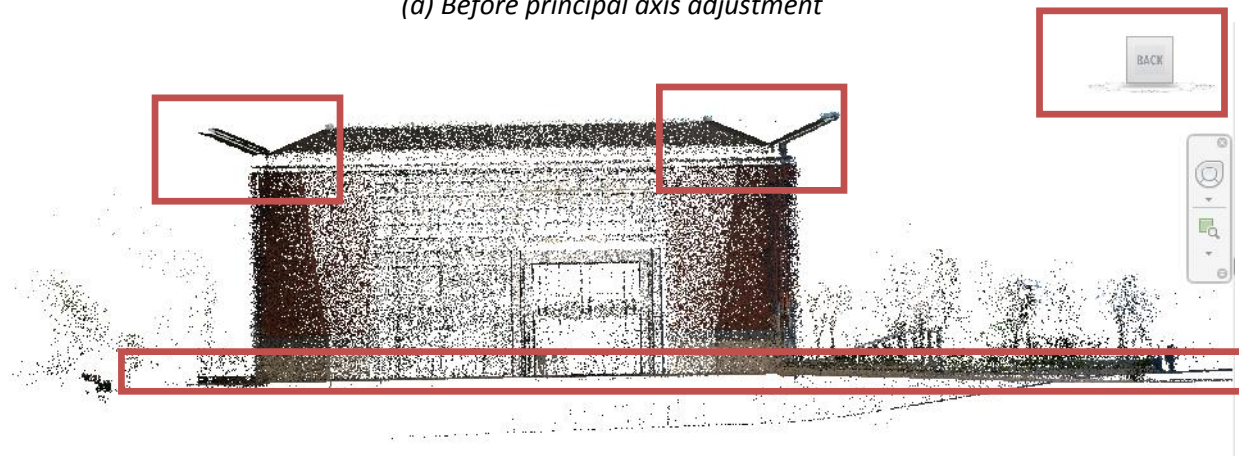
(b) After principal axis adjustment

Figure 3 : Adjust axis tool

In Figure 3, only X/Y axes are adjusted. While in the following Figure 4, X/Y/Z axes are all adjusted; notice the difference shown in the red regions;



(a) Before principal axis adjustment



(b) After principal axis adjustment

Figure 4: Adjust axis tool

4 Datum Extraction

Tools are provided to extract levels and grids from point cloud data to facilitate the definition of stories and layout of the building.

4.1 Extract Level

4.1.1 Workflow



Extract
Level

1. Select **Extract Level** tool.
2. Select points for level extraction; the tool only extracts the levels existing in the selected points;
3. Set the options for level detection; Option setting will be introduced in section 4.1.2;
4. Levels will be automatically created at detected floor / ceiling locations location; User can edit or erase the created levels as necessary;

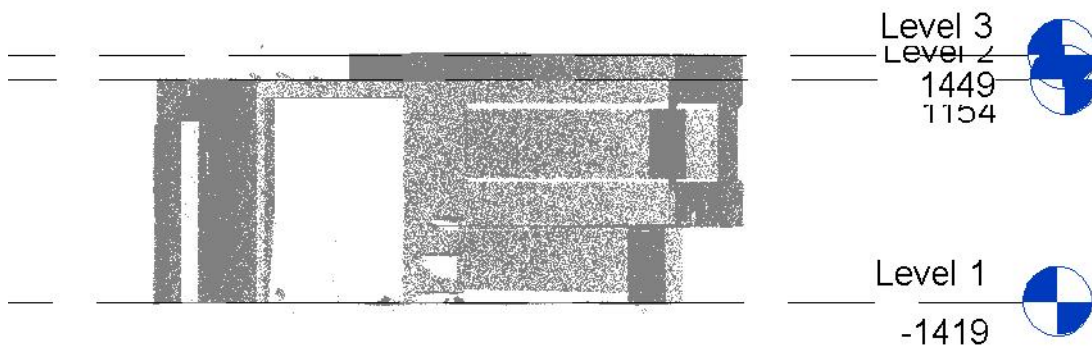


Figure 5: Levels are created at potential floor / ceiling locations



Tips: Sometimes the created levels are too short to see when the point cloud is of large scale;



In this case, user can use the **Hide Point Cloud** tool to temporarily hide the point cloud to view the extracted levels; user can right click on the level and use 'Maximize 3D Extents' to extend the level.

4.1.2 Parameter Setting

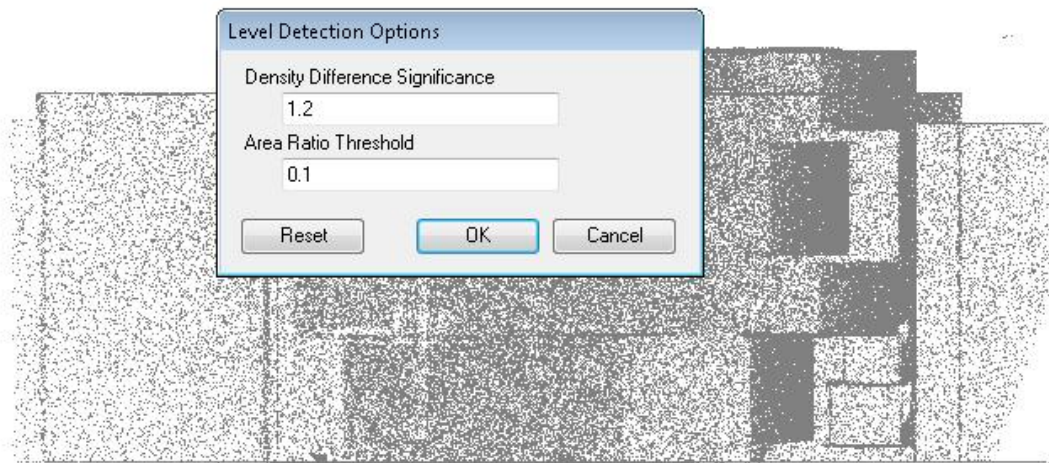



Figure 6: Option setting for level detection

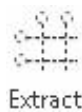
- **Density Difference Significance**
The level is detected based on the density difference of the points in different levels along z axis. Density difference means the deviation from the number of points in on level height to the mean point number in its neighboring height. Significance is represented by coefficient of the density difference to the standard deviation of the density difference in neighboring height regions. The smaller this parameter, the more levels will be detected;
- **Area Ratio Threshold**
The minimum ratio of the area a level covers to the area the whole building covers. This is used to suppress the detection of objects such as big tables; the smaller this parameter, the more levels will be detected;

4.2 Extract Grid

This tool helps to extract the column grids from the selected points. The extracted grids can help user to create elements from the point cloud.

 **NOTES:** The extracted grids are restricted to be orthogonal and are aligned with X/Y axis; as the grid line extraction is based on the wall layout, user should rotate the point cloud data first if the major walls are not aligned with X/Y axes;

4.2.1 Workflow



1. Select **Grid** tool.
2. Select points to extract grids. The selected points should include the points on the major walls;
3. Set the options for grid extraction; Option setting will be introduced in section 4.2.2.
4. Grids will be automatically created at detected wall locations; user can edit or erase the created grid as necessary;

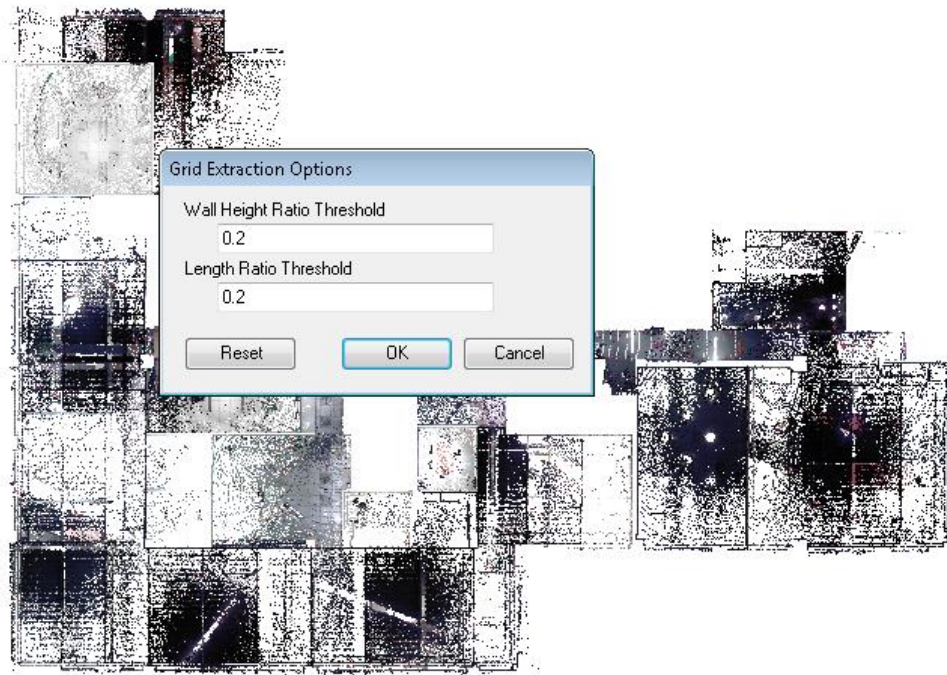


Figure 7: Set option for grid extraction

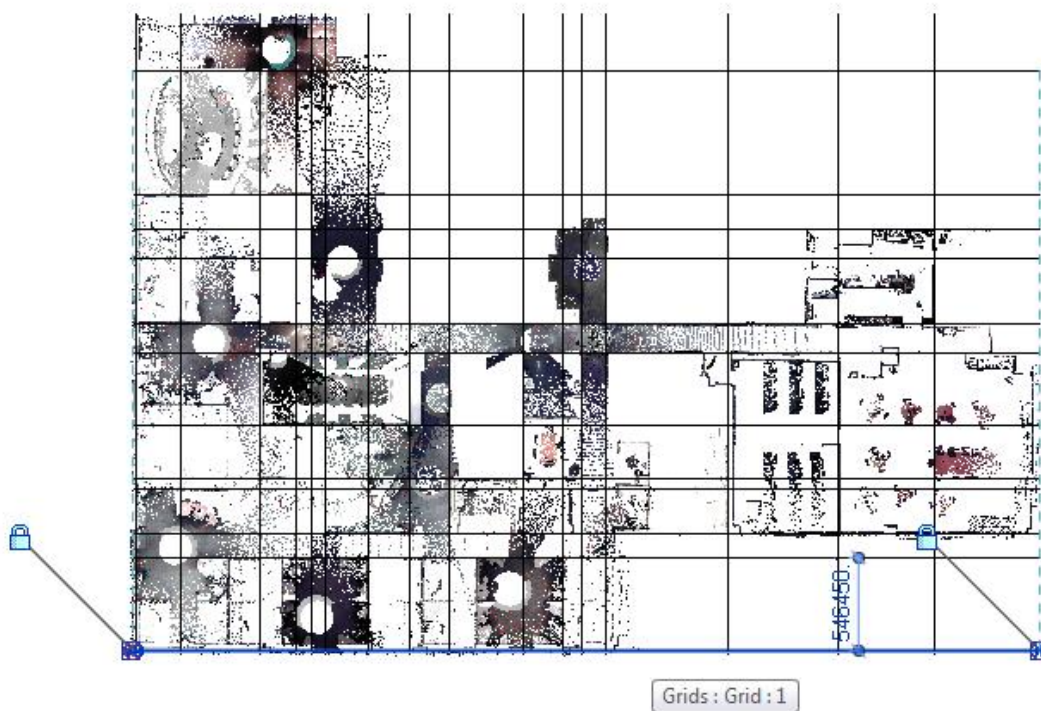
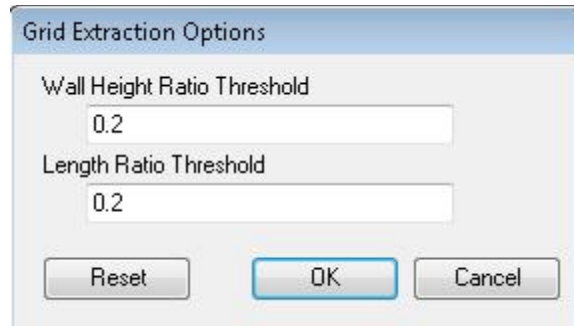


Figure 8: Levels are created at potential floor / ceiling locations

4.2.2 Parameter Setting



– Wall Height Ratio Threshold

Walls with opening doors/windows or walls made of glass will not be captured completely by laser scanners, thus leaving holes in the wall. If ratio of the height of captured wall points along z axis to the wall height covers more than wall height ratio threshold, this part of points are regarded as wall points and used for grid extraction

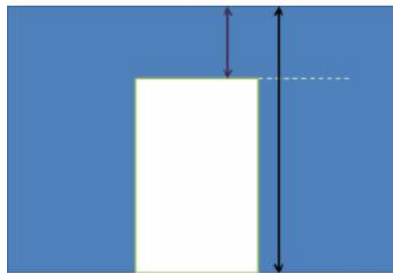


Figure 9: The part above the opening will also be regarded as wall if the wall height ratio threshold is properly set

– Length Ratio Threshold

For a valid grid, the ratio of the accumulated wall length along the grid to the extent of the whole building should exceed length ratio threshold; the smaller this parameter, the denser grids will be generated.

5 Site Extraction

Site extraction helps to extract the toposurface in the point cloud data and the outline of the building.

5.1 Site Surface

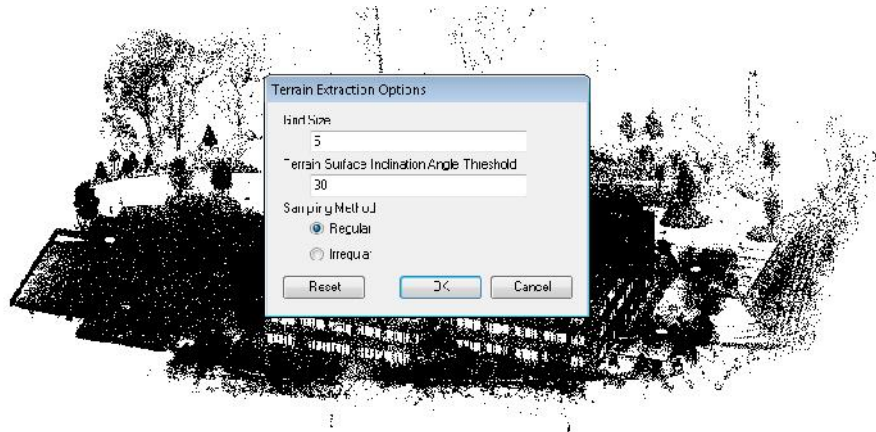
5.1.1 Workflow



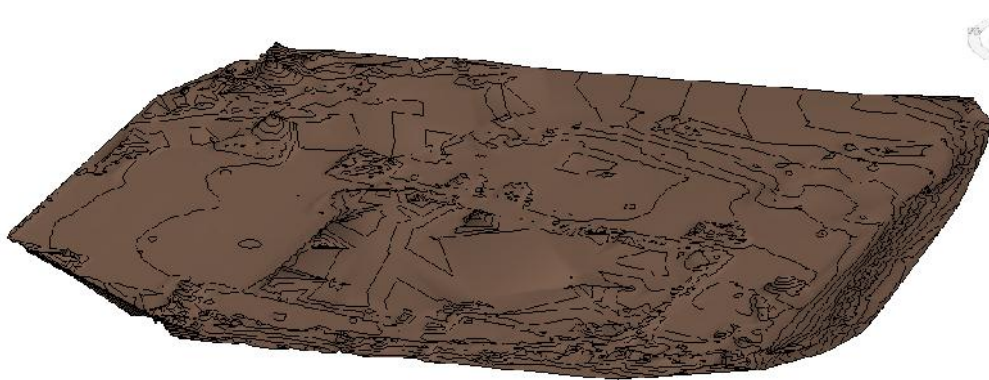
Site

1. Select **Surface** tool.
2. Select points with aided Rectangle. The selected points should not contain too many object points to avoid disturbance of some noisy points;

3. Set the options for terrain extraction;



4. A terrain surface will be generated using only sample points from the extracted terrain points in the point cloud data.



(a) Extracted site surface

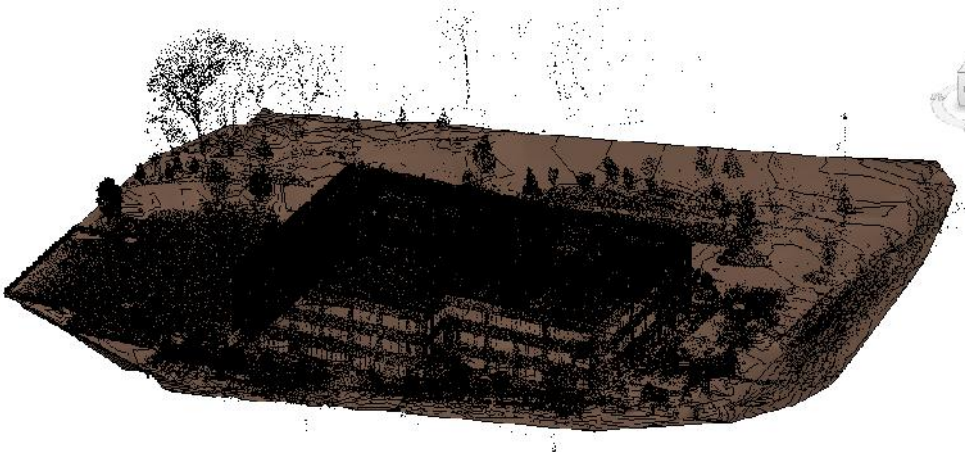
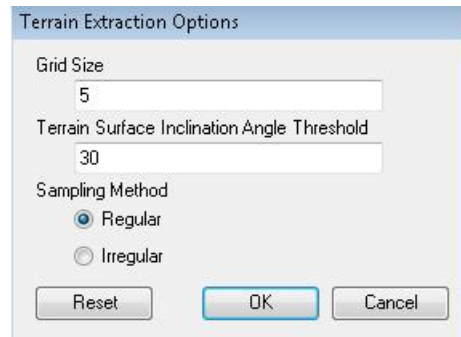


Figure 10: Site surface extraction tool

5.1.2 Parameter Setting



- **Grid size:**

The whole point cloud site will be subdivided into small stripes along the principal axis of the site. Ideally, the shape of the terrain surface in one grid does not vary a lot. Grid Size controls the resolution of stripe size and the resulting site surface.

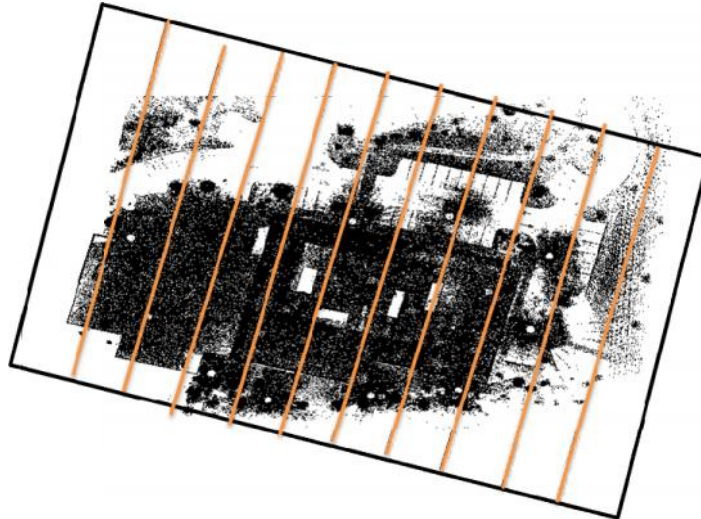


Figure 11: The whole point cloud is divided into stripes for terrain extraction according to the grid size

- **Terrain Surface Inclination Angle Threshold**

The maximum inclination angle existing in the terrain surface; User can adjust this parameter according to the shape of the terrain. As the parameter increases, more object points may be included into the terrain surface.


- **Sampling Method**

- **Regular**

Middle point of a terrain grid will be used to generate the site surface, thus generating regular triangulation of the site surface;

- **Irregular**

Mean point of a terrain grid will be used to generate the site surface;

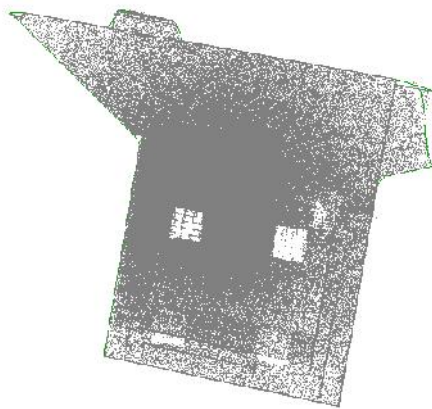
 **Tips:** If there are some jump-out points in the resulting terrain mesh, user can adjust the parameters of Tile Size and Grid Size to get better result and better performance.

5.2 Building Footprint

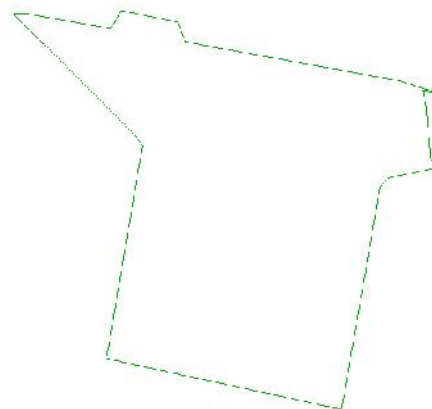
5.2.1 Workflow



1. Select Building Footprint tool.
2. Select points with aided Rectangle. Selected points should not contain points out of the building, otherwise, the footprint result may be effected;
3. Set the options for building footprint generation. Parameter setting will be introduced in the section 5.2.2.
4. Outline of the footprint can be used to generate a building pad on the extracted site surface.



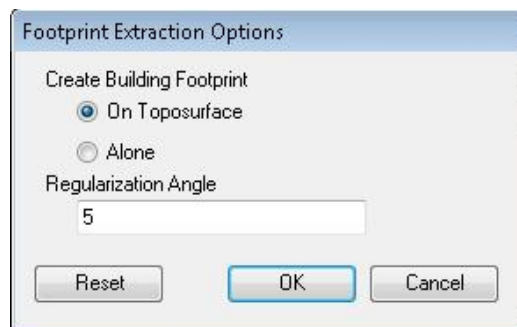
(a) Point cloud from top view



(b) Extracted building footprint

Figure 12 : Building footprint generation

5.2.2 Parameter Setting



– Create Building Footprint

This option is used to set location of the generated footprint.
There are two options provided:

- **On Toposurface:** User needs to select an existing toposurface in the project and then the footprint will be generated on the toposurface;
- **Alone:** The footprint will be placed at the lowest position of the selected points.

Tips: If user wants to create building pad from the building footprint, the level for the building pad should be correctly set beforehand.

– Regularization Angle

For most building footprint, the wall layout is regular. Regularization angle is used to adjust the building footprint result by forcing lines with angle with $[0, \text{regularization angle}]$ to be parallel and line with angle within $[90 - \text{regularization angle}, 90]$ to be perpendicular. If you want to keep the original polygon result, you can set this value to 0.

6 Wall Extraction

6.1 Straight Wall

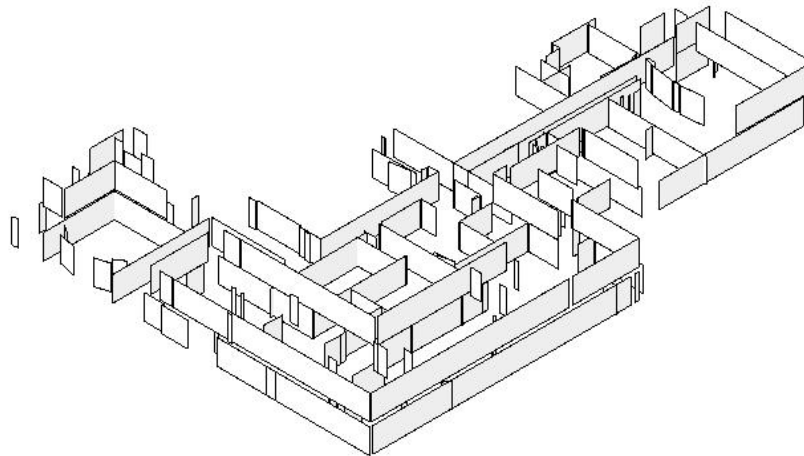
6.1.1 Workflow



1. Select Straight Wall tool.
2. Select points with aided Rectangle.
3. Set the options for straight wall generation. Parameter setting will be introduced in section 6.1.2.
4. A layout of the main straight walls will be generated. Noted from the following figures that the layout is not perfect, so user needs to make modification on the extraction result.




(a) Extracted wall layout



(b) Extracted walls from point cloud data

Figure 13: Straight wall generation

 **NOTES:** The generated wall layout depends on the levels created in the project; Points between two levels are selected and used for layout generation separately;

6.1.2 Parameter Setting

– Model Line

This option is used to control the extraction of model lines for the straight walls.

- **Wall Height Ratio Threshold:** Walls with opening doors/windows or walls made of glass will not be captured completely by laser scanners, thus leaving holes in the wall. If ratio of the height of captured wall points along z axis to the wall height cover more

than wall height ratio, this part of points are regarded as wall points; (Similar as the one in 'Extract Grid' tool)

- **Minimum Wall Length Coefficient w :** Model lines shorter than **(MeanDistance * w)** will be regarded as noise lines and are erased;



NOTES: The value of **MeanDistance** is adaptively adjusted by the scale of the point cloud and the unit used for this project. So user doesn't need to care about the scale and the unit;

- **Minimum Gap Length Coefficient g :** If the distance between two model line segments on the same line is shorter than **(MeanDistance * g)**, these two model line segments are connected to form one line segment; otherwise, a gap is leaved between these two model line segments;

– Wall

This option is used to set the options for generating wall elements from the extracted model lines;

- **Type:** Specify the wall type; this wall type will be applied to all the automatically generated walls;
- **Height:** Specify the height of the wall
 - **Vary with level height:** this height value of the wall of each level will vary according to the distance between levels which points are located between.
 - **Custom:** If 'Custom' item is checked, user can optionally set a custom height value; the value is default set to be the distance between level1 and level2;



Tips: As the height of the walls depends on the level setting, user should use the '**Extract Level**' tool to create the correct levels first before generating the straight wall. In this way, wall height will be automatically correctly set;

6.2 Arc Wall

6.2.1 Workflow



1. Select **Arc Wall** tool.
2. Select points with aided Rectangle. it would be better if the selected points contain only the arc wall region;
3. Specify a seed point in the selected points;
4. Set the options for arc wall generation. Parameter setting will be introduced in section 6.2.2.
5. Arc wall with specified type will be generated. The height of the wall will be automatically determined by the extent of points on the arc wall.



Tips: You need to select a portion of points which contains an arc wall, and then select a seed point belonging to the arc wall points. You can select the seed point from a Level view or a top view.

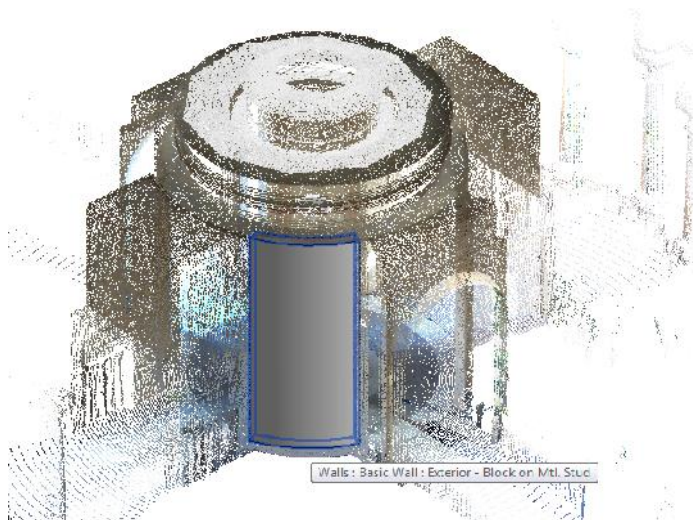
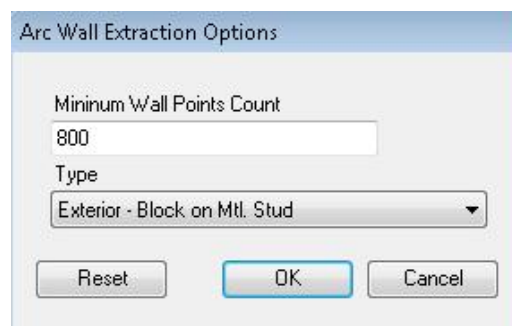


Figure 14: Extract arc wall from point cloud

6.2.2 Parameter Setting



- **Minimum Wall Points Count**
Minimum number of points required by an arc wall
- **Type** Specify the type of the generated arc wall;

7 Floor Extraction

7.1 Floor

7.1.1 Workflow



1. Select **Floor** tool.
2. Select points with aided Rectangle. It would be better if the selected points contain only points from the floor.
3. Set the options for floor generation.

4. Floors with specified type will be generated at corresponding levels that the selected points are located between. If the boundary of the floor is not satisfying enough, user can edit the boundary of the floor by Revit tools;

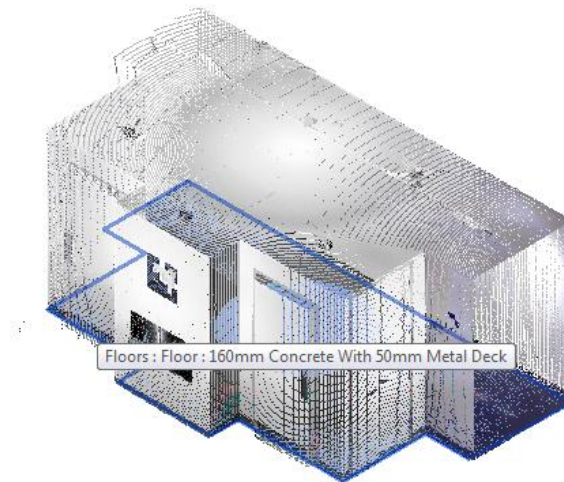
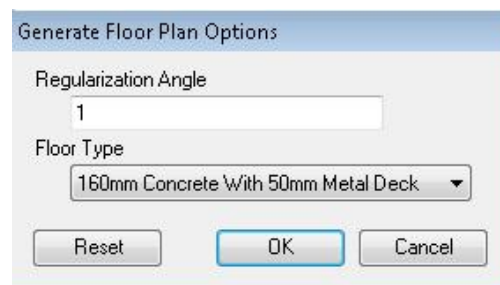


Figure 15: Extract floor from point cloud

Tips: User can select a small region to contain points of the floor to be extracted only to extract one floor each time. Also, user can select all the points to generate floors for each level. Points for each level will be classified by the existing levels. Thus, correctly setting the level beforehand is important for floor extraction;

7.1.2 Parameter Setting



- **Regularization Angle**
For most building footprint, the wall layout is regular. Regularization angle is used to adjust the building footprint result by forcing lines with angle with $[0, \text{regularization angle}]$ to be parallel and line with angle within $[90 - \text{regularization angle}, 90]$ to be perpendicular.
- **Floor Type**
Specify the type of the generated floor;

8 Known Issues

1. Redo and Undo are not supported by the **Crop/Uncrop, Hide/Show Point Cloud** tools.
2. If the point cloud density varies a lot in floor regions, the boundary of the floor might not be regular enough;