PointCloud2BIM_UI
User Manual

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Obtaining the application

The application can be obtained from the Department of Mechanics, Faculty of Civil Engineering, Czech Technical University. Please send a request to borek.patzak@fsv.cvut.cz for licensing options.

Introduction

The 3D laser scanning is a convenient and accessible technology to document the existing infrastructure, including buildings. The output is a set of data points in space, so-called point clouds. While point clouds can be directly rendered and inspected, they need to be converted into BIM representation for efficient digital processing.

The PointCloud2BIM_UI is a user interface built on top of PointCloud2BIM library. It provides access to the top-level algorithms (floor, room, wall, and opening detection) of the PointCloud2BIM library from a graphical user interface (GUI). The description of the segmentation process is available in the PointCloud2BIM User Manual [3].

Each project is stored and maintained in an individual folder. The folder contains a single project file in the JSON format and stores each point cloud points in separate binary files for efficient reading/writing.

After the opening of the PointCloud2BIM_UI, the welcome screen (Fig. 1) is available to create a new project or to manage the existing one. Furthermore, the PointCloud2BIM_UI workflow is divided into six subsequent steps, which correspond to the PointCloud2BIM library binaries. The typical steps involved in point cloud transformation into a digital BIM model is shown in Fig. 2. These steps are available in the UI using their individual tabs (Fig. 3).
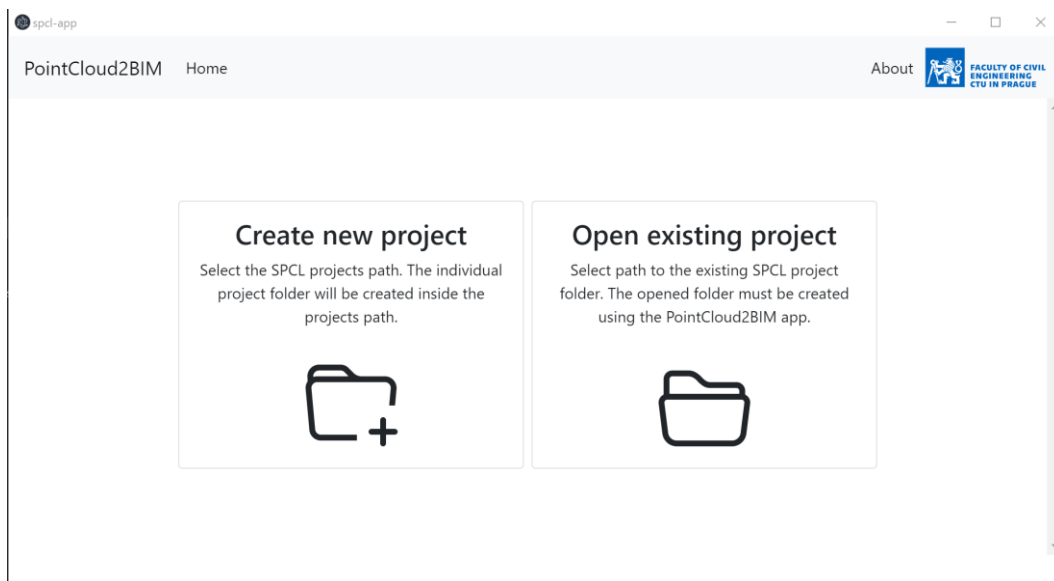

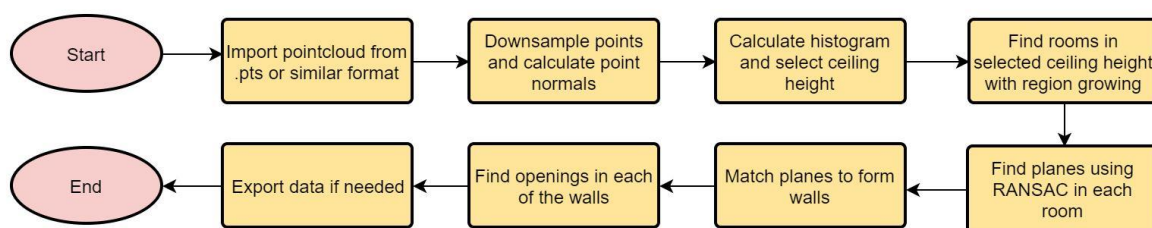
Figure 1: The application welcome screen.

Figure 2: Typical steps involved in point cloud transformation into digital BIM model.
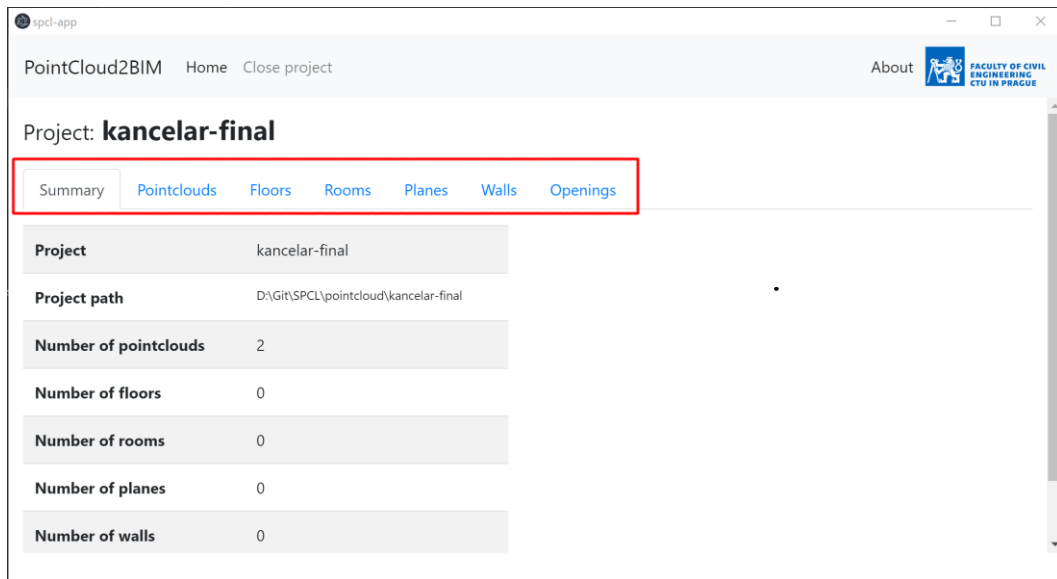
Figure 3: Each of the segmentation steps is available in the tab menu (marked in red).

Requirements

- PointCloud2BIM_UI is built in JavaScript and requires a standard Node.js environment. It can be compiled into its respective binaries on Unix/Linux systems and Windows systems using Electron.js framework.

Build steps

- Run the command line inside the project folder
- The PointCloud2BIM library binaries must be placed into the extra-resources-folder for the corresponding operating system
- The application is built by running the **npm run electron:build** command
- The Development version is accessible via the **npm run electron:serve** command.

Available steps

PointCloud2BIM_UI uses the PointCloud2BIM library routines in the background by running the individual command-line scripts in the background. Each of the commands and its inputs is described in [3]. The user interface provides a listing of the existing entities and user-friendly menus for the gradual segmentation of the BIM entities.

Point clouds

The point cloud management is available under the **Pointclouds** tab. It provides two action buttons, one for import and one for downsampling of the point cloud. All available project point clouds are summarized in a table. The typical point clouds include imported points, downsampling, and individual room/plane/wall point clouds.

Import

Points in the PTS or PTX format (1 point per line, space-separated values) can be imported to the project. Such a point cloud can be obtained, for example, by the Autodesk ReCap application.
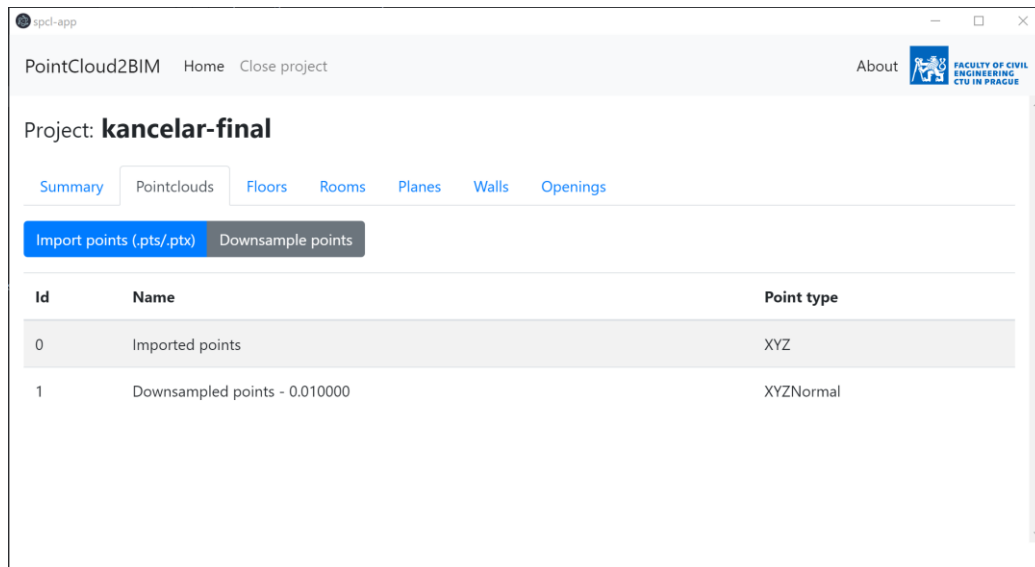

Figure 4: View of the Point clouds tab

Downsampling

Downsampling is convenient to reduce the total number of points for individual entity segmentation. The downsampling dialog is shown in Fig. 5. A single point cloud is selected (typically the input point cloud), which is downsampled in a uniform voxel grid of a given step. A step length of 10-20 mm is appropriate for most of the applications. Furthermore, the point normal vector can be calculated for each of the downsampled points. This is required for vertical wall segmentation.
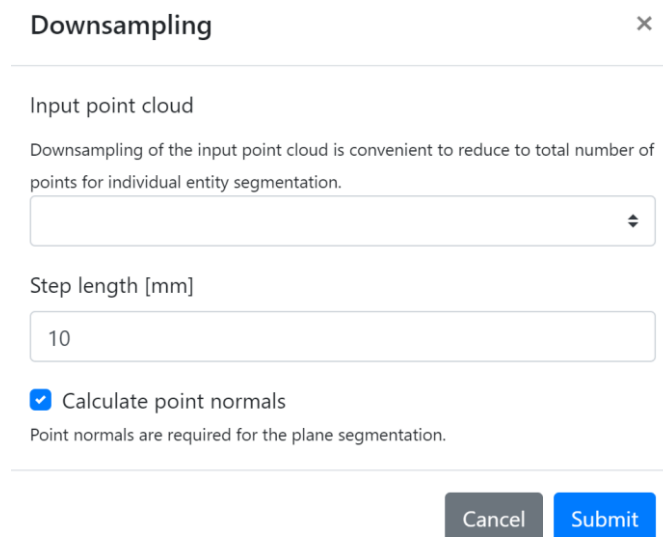

Figure 5: Point cloud downsampling dialog showing the available options.

Floors

The project may contain multiple floors, or a single floor can be segmented using different input parameters. These individual segmentations are then stored as separate floors. View of the typical floor listing with a single floor is shown in Fig. 6.
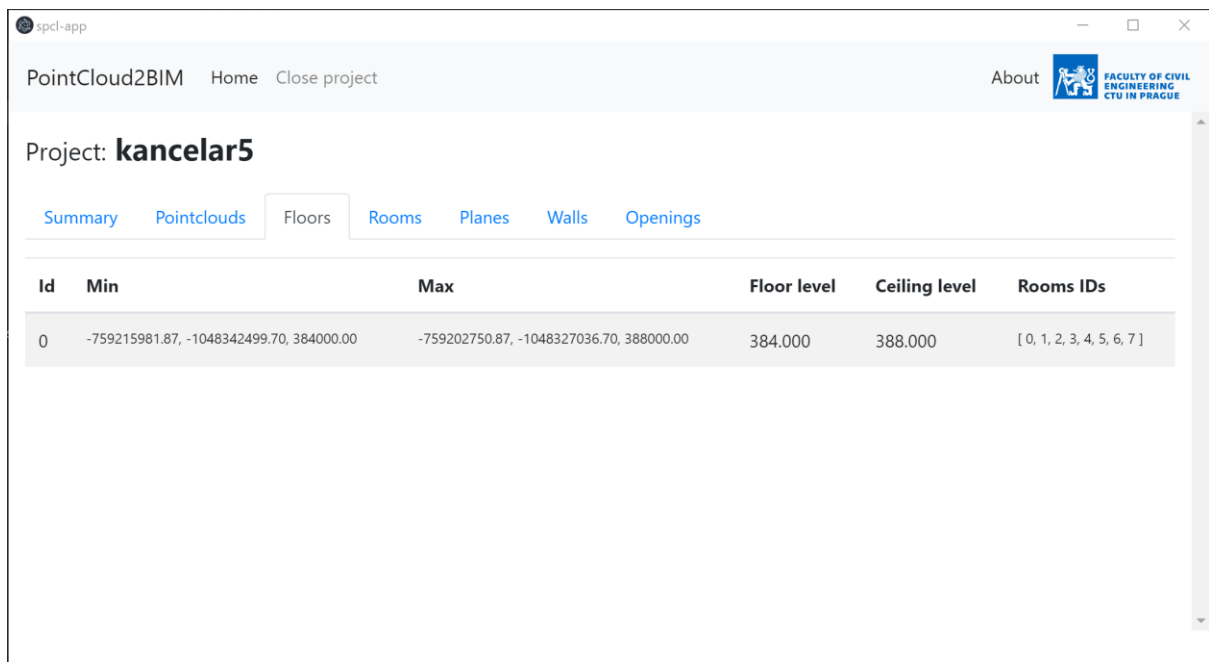
Figure 6: View of the floor listing tab.

Rooms

Room segmentation is available in the **Rooms** tab. The rooms list (see Fig. 7) contains the bounding box (min, max columns) of the room, the calculated floor and ceiling levels, and segmented planes (if any). Each room may consist of one or multiple point clouds (i.e., merged rooms may have 2 point clouds). The action buttons allow for individual PTX export or 3D visualization of the rooms using Easy3D renderer.

Figure 7: View of the room listing tab.

The room segmentation options are summarized in Fig. 8. If the downsampled point cloud is selected as the input point cloud, the step length must be at least twice the downsampling step to avoid missing points. A usual step of 20 mm is sufficient for the 10 mm downsampling step. Z-levels are taken from the histogram of Z point coordinates. Vertical planes can be found during room

segmentation, which is required for further wall segmentation. Missing points can be filled inside the room floor plan for precise area calculation.

Figure 8: View of the room segmentation dialog.

Planes

The plane segmentation is done during room segmentation. The **Planes** tab only contains a list of planes, which can be further used to identify walls. The normal vector is calculated for each plane, and plane points are stored separately in a sub-point cloud. The typical plane overview can be seen in Fig. 9.

Id	Floor	Min	Max	Normal vector	Pointcloud IDs
0	0	-759204752.04, -1048342499.70, 384000.01	-759203647.87, -1048334683.53, 386891.94	-0.99, 0.13, 0.01	[3]
1	0	-759206829.47, -1048334691.70, 384000.00	-759203670.62, -1048334256.56, 386868.14	-0.14, -0.99, 0.00	[4]
2	0	-759207868.87, -1048342069.30, 384000.01	-759206819.20, -1048334281.70, 386891.94	-0.99, 0.13, 0.00	[5]
3	0	-759207842.47, -1048342499.37, 384090.94	-759204738.87, -1048342053.20, 386699.94	0.14, 0.99, 0.00	[6]
4	0	-759208072.87, -1048341903.70, 384109.69	-759207631.37, -1048338814.81, 386959.27	-0.99, 0.13, 0.00	[8]
5	0	-759210046.87, -1048341997.90, 384108.94	-759209530.01, -1048338557.70, 386945.94	-0.99, 0.13, 0.00	[9]
6	0	-759209971.87, -1048342025.20, 384117.19	-759208261.87, -1048341777.37, 386951.94	0.13, 0.99, 0.00	[10]
7	0	-759209532.62, -1048338835.70, 384119.01	-759207638.01, -1048338560.70, 386947.94	0.14, 0.99, 0.00	[11]
8	0	-759210181.44, -1048341977.20, 384106.69	-759209691.87, -1048338540.70, 387008.94	-0.99, 0.13, 0.00	[13]
9	0	-759215316.44, -1048336879.70, 384117.94	-759210089.62, -1048336167.20, 387026.44	-0.13, -0.99, 0.00	[14]
10	0	-759210811.54, -1048341892.59, 384111.44	-759210091.04, -1048336880.70, 387004.94	-0.99, 0.14, 0.00	[15]
11	0	-759215826.27, -1048341805.87, 384109.94	-759210101.12, -1048341012.70, 387041.27	0.13, 0.99, 0.00	[16]

Figure 9: View of the plane listing tab.

Walls

The **Walls** tab facilitates the wall segmentation from individual vertical planes. Planes from each of the rooms are matched to the planes in the other rooms to avoid matching invalid walls within a

single room. The wall finding algorithm works on a selected floor. The minimal and maximal wall thickness should be defined according to the expected wall thickness (typically 100-500 mm). Furthermore, the minimal wall length (in the floor plan direction) is specified to reduce invalid matches. The wall finding options can be seen in Fig. 10.

Figure 10: View of the wall segmentation dialog.

The overview of the already segmented walls can be seen in Fig. 11. The calculated parameters include wall thickness, length, type (outer/inner), and information suitable for import into the existing CAD software (insertion point, director vector). Each of the walls can be exported as a standalone point cloud or viewed in 3D using the Easy3D viewer.

Id	Floor	Wall thickness	Wall length	Outer	Insertion point	Director vector	Plane IDs	Actions
0		179.065	3113.495	no	-759207986.14, -1048341915.45, 384095.94	-0.15, -0.99, 0.00	[39, 40]	Export .PTX 3D
1		107.344	3464.932	no	-759209616.54, -1048338553.33, 384088.94	0.14, 0.99, 0.00	[41, 42]	Export .PTX 3D
2		167.236	4480.983	no	-759207500.99, -1048338714.51, 384092.94	-0.12, -0.99, 0.00	[43, 44]	Export .PTX 3D
3		109.635	2495.681	no	-759210079.56, -1048336774.87, 384092.94	0.99, -0.11, 0.00	[45, 46]	Export .PTX 3D
4		114.757	1893.901	no	-759207646.96, -1048338774.13, 384092.94	0.99, -0.16, 0.00	[47, 48]	Export .PTX 3D
5		91.646	1439.190	no	-759210015.81, -1048336893.73, 384092.94	0.16, 0.99, 0.00	[49, 50]	Export .PTX 3D

Figure 11: Overview of the segmented walls. Insertion point and director vector allow for import to the existing CAD applications.

Openings

The **Openings** tab is the final step in the PointCloud2BIM segmentation process. The openings are found in the existing walls using several parameters. At first, a floor is selected to fetch its existing walls. Then, the input point cloud is selected (full or downsampled). A step length of either the double of downsampling step or any step (if using full point cloud) is selected. The values of the two coefficients – "Inner points coefficient" and "External wall thickness tolerance" were already found

by trial and error. These can be further tweaked for the individual point clouds to improve opening finding performance. All the input parameters can be examined in Fig. 12.

Find walls on a given floor ×

Select floor

Walls will be matched for all rooms in a given floor

#0 - 8 místností ⇕

Min. wall length [mm]

1000

Min. wall thickness [mm]

100

Max. wall thickness [mm]

500

Cancel Submit

Figure 12: View of the opening segmentation dialog.

The segmented openings can be observed in a table (See Fig. 13). The type (doors/window) is determined as well as dimensions. The corner coordinates are calculated for easy export into the existing CAD programs. Individual opening point clouds can also be exported in the PTS format.

Summary	Pointclouds	Floors	Rooms	Planes	Walls	Openings

Find openings

Id	type	dimensions	x corner coords	y corner coords	z corner coords	actions
0	door	860.00 x 1940.00	-759207580.93, -759207693.24, -759207693.24, -759207580.93	-1048339083.06, -1048339935.69, -1048339935.69, -1048339083.06	384153.04, 384153.04, 386093.04, 386093.04	Export .PTX 3D
1	window	100.00 x 1520.00	-759210092.87, -759210081.65, -759210081.65, -759210092.87	-1048341935.33, -1048341835.93, -1048341835.93, -1048341935.33	386771.05, 386771.05, 385251.05, 385251.05	Export .PTX 3D
2	door	820.00 x 1960.00	-759209772.22, -759209665.14, -759209665.14, -759209772.22	-1048339556.84, -1048338743.86, -1048338743.86, -1048339556.84	386091.05, 386091.05, 384131.05, 384131.05	Export .PTX 3D
3	door	1620.00 x 1940.00	-759207783.42, -759209389.04, -759209389.04, -759207783.42	-1048338726.77, -1048338511.38, -1048338511.38, -1048338726.77	384169.14, 384169.14, 386109.14, 386109.14	Export .PTX 3D
4	window	960.00 x 500.00	-759212631.79, -759212509.37, -759212509.37, -759212631.79	-1048336269.31, -1048335317.15, -1048335317.15, -1048336269.31	386099.86, 386099.86, 385599.86, 385599.86	Export .PTX 3D
5	window	980.00 x 820.00	-759212485.47, -759212360.98, -759212360.98, -759212485.47	-1048335138.74, -1048334166.68, -1048334166.68, -1048335138.74	386119.86, 386119.86, 385299.86, 385299.86	Export .PTX 3D

Figure 13: Overview of the segmented openings. Insertion point (calculated as the average of the corner points – the center point) and dimensions allow for import to the existing CAD applications.

Example

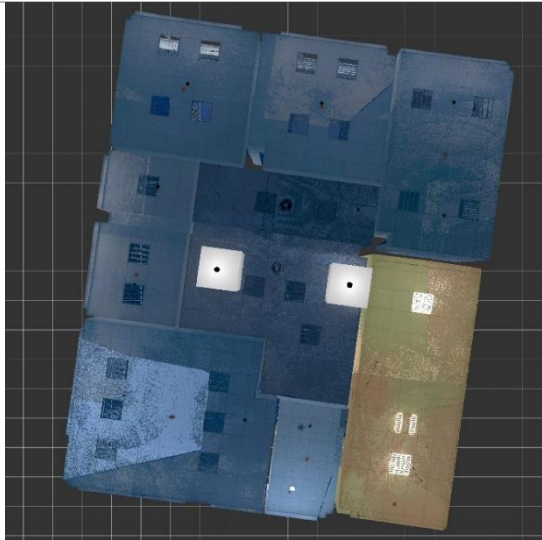The examples are described in detail in the PointCloud2BIM library manual [1].

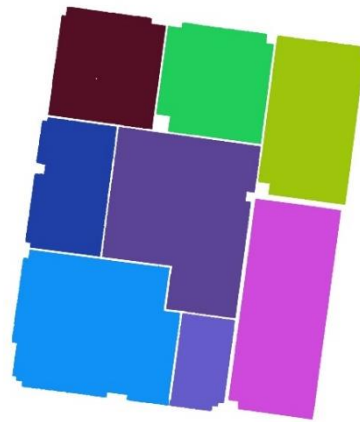Fig. 14.1 Original point cloud visualization
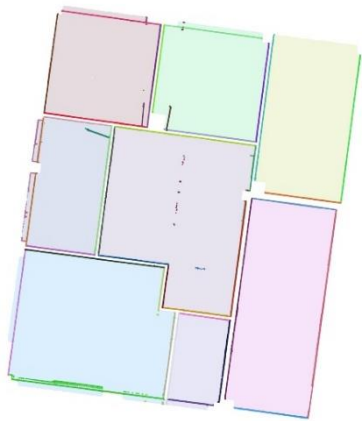

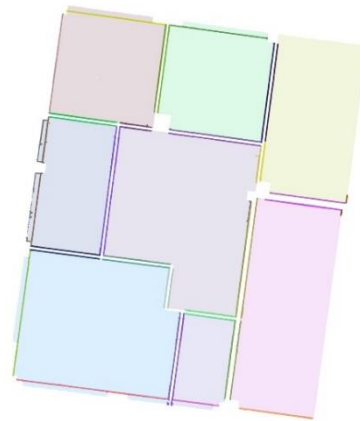Fig. 14.2 Detected rooms

Fig. 14.3: Identified vertical planes

Fig. 14.4: Identified walls
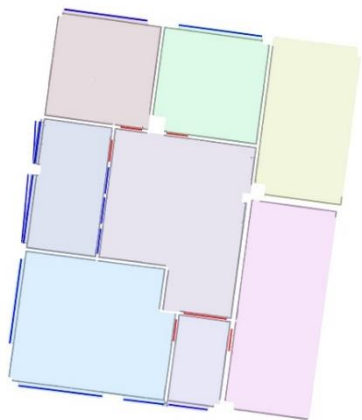
Fig. 14.5 Identified openings (top view)
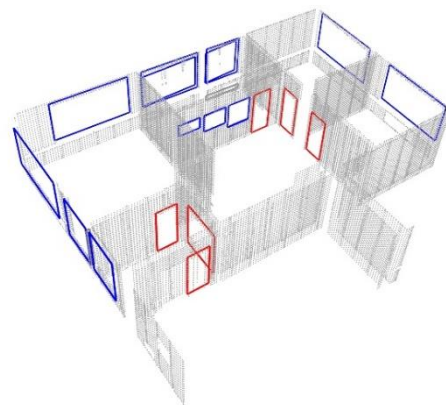
Fig. 14.6 Identified openings (perspective)

Acknowledgement

References

(1) E. Dvořáková, P. Patzák, D. Rypl, J. Voříšek: PointCloud2BIM library Reference manual, available online at http://mech2018.fsv.cvut.cz/pc2bim/doku.php, 2020.
(2) E. Dvořáková, P. Patzák, D. Rypl, J. Voříšek: PointCloud2BIM library web pages, http://mech2018.fsv.cvut.cz/pc2bim/doku.php, 2020.
(3) E. Dvořáková, P. Patzák, D. Rypl, J. Voříšek: PointCloud2BIM library Reference manual, available online at http://mech2018.fsv.cvut.cz/pc2bim/lib/exe/fetch.php?media=docs:pointcloud2bim_user_manual_v1_4_.pdf, 2020.