Semi-automated building extraction from airborne laser scanning data on the example of the central campus of Warsaw University of Technology

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ABSTRACT

The main idea of this project is to introduce a conception of method of semi-automated building extraction from Airborne Laser Scanning data. The effects will be presented on the example of the Central Campus of Warsaw University of Technology.

Airborne LIDAR has become a very popular technique for acquisition of terrain elevation models and lately, also of covering the area. Creating studies based on LIDAR data is more and more universal solution in commercial, marketing, scientific, architectural and engineering fields. Due to the high density of acquired points and increasing received accuracy, this method is very useful in generation of three-dimensional models of cities, regions or individual objects of the highest level of detail possible to achieve.

The main goal of realized project was to find the most effective algorithm of automatic acquiring planes for roofs. Effects of this algorithm were proceeded in software such as ArcGIS, SketchUP to generate roofs and finally to make complete building models. Based on partly semi-automatic and partly manual method, can provide models at the level of detail LoD 2 CityGML standard.

INTRODUCTION

Airborne LIDAR has become a very popular technique for acquisition of terrain elevation models and lately, also of covering the area. Creating studies based on LIDAR data is more and more universal solution in commercial, marketing, scientific, architectural and engineering fields. Due to the high density of acquired points and increasing received accuracy, this method is very useful in generation of three-dimensional models of cities, regions or individual objects of the highest level of detail possible to achieve.

Nowadays, the problem of low computational power of computers does not exist. Therefore, there are powerful numerical algorithms involved, allowing the fully automatic processing of point cloud and detection of coherent components.

METHODS

In the research were used data from the Polish project of flood prevention “ISOK”, for which were made airborne laser scanning of nearly 90% area of Poland. ALS data is provided in two standards of accuracy:

- Standard I : minimal density of cloud 4 pts/m2
- Standard II : minimal density of cloud 12 pts/m2

The main goal of realized project was to examine the effectiveness of the algorithm RANSAC automatic acquiring planes for roofs. The algorithm RANSAC (Random Sample

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Consensus) was presented for the first time at the Stanford Research Institute International in 1981 by Martin Fischler'a and Robert Bolles'a. This algorithm allows to estimate the model on a sample containing outliers (Fischler, Bolles, 1981). For this reason, it is ideal for the analysis of data from devices whose observations are burdened with some kind of error. In the case of Airborne Laser Scanning, the algorithm can process point clouds burdened with noise and erroneous measurement. RANSAC principle of operation is based on the iterative processing of a set of points in order to estimate the geometric model.

RESULTS

In order to test various parameters of the algorithm Cloud Compare software has been used. This open source program has RANSAC plugin, which contains modified algorithm made by Ruwen Schnabel in 2007.

The algorithm has got 5 parameters corresponding to the detection planes:

- *Minimal points support per primitive*
- *Epsilon* – error tolerance. Geometric buffer qualifying points to the plane.

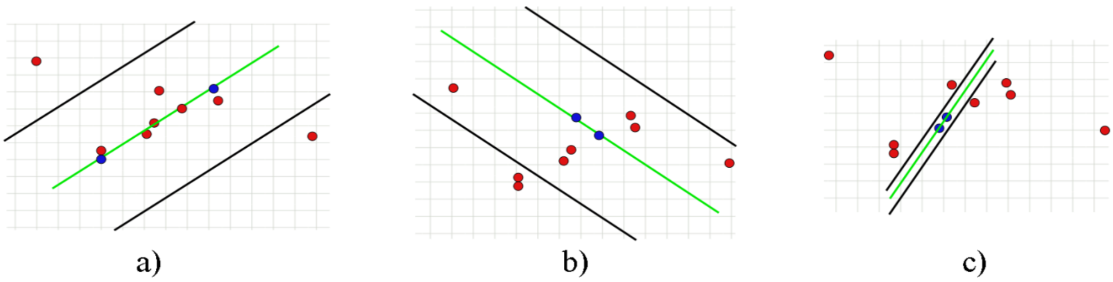

Figure 1: Epsilon selection example a) correct solution, too big epsilon b) incorrect solution, too big epsilon c) incorrect solution, too small epsilon (wikipedia)

- *Bitmap epsilon* – parameter used to segmentation of data set. Value depends from point cloud density.

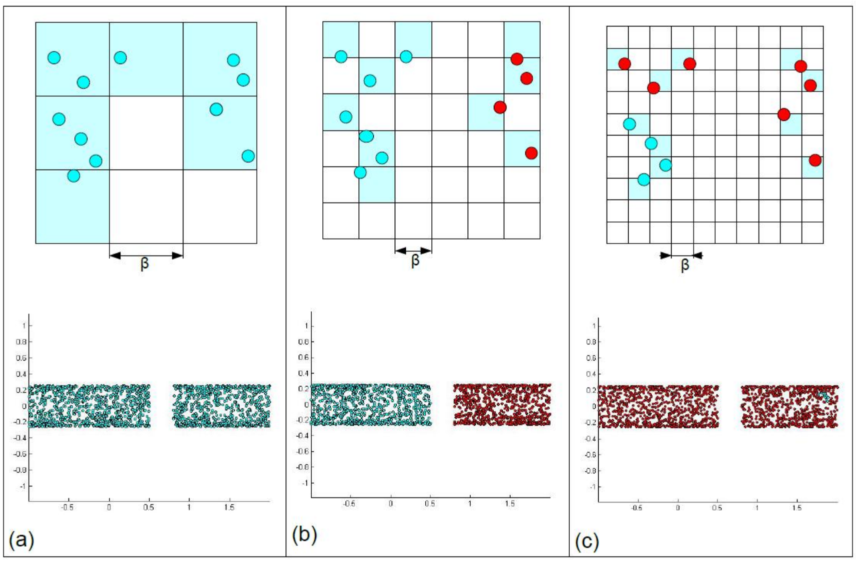

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Figure 2: Bitmap epsilon selection example a) too big b) optimal c) too small (Trofimov, 2010)

- *Normal Threshold* – value of the probability with which the plane is detected
- *Probability* – parameter responsible for the completion of the iteration process.

Depending on the choice of parameters received a different number of surfaces with different accuracies.

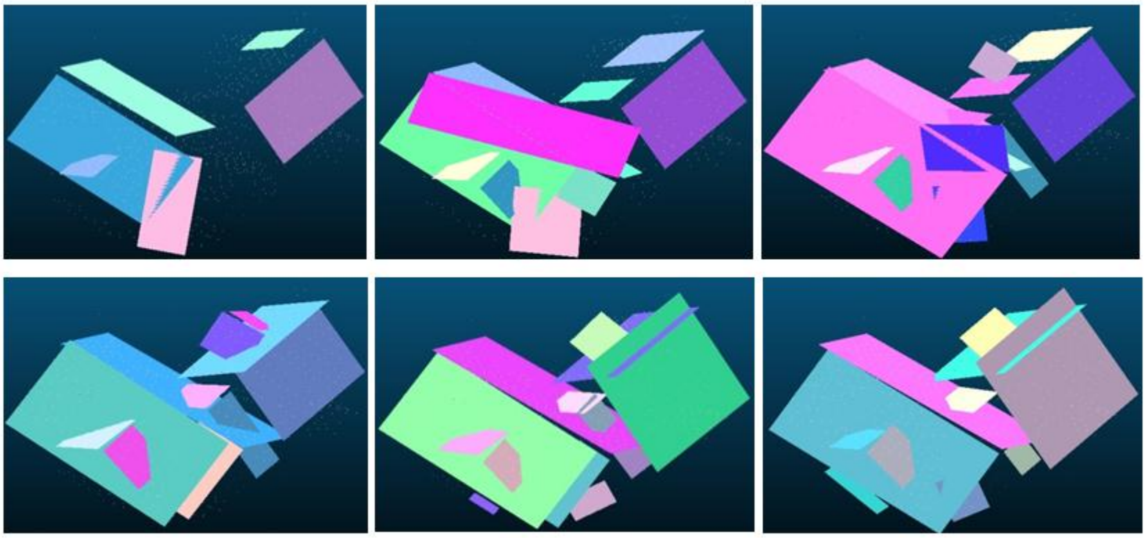

Figure 3: Example of planes obtained depending from Normal Threshold parameter.

In case of clouds with density of 4 pts/m2, the best results are obtained with the following parameters:

- Minimal points support per primitive: 18-30pts
- Epsilon: 0,10-0,15m
- Bitmap epsilon: 0,5
- Normal Threshold: 0,95
- Probability: 0,001

The minimum value to correctly determine the position of small parts of roofs is 4 pts/m2 . RANSAC algorithm tests were carried out on a cloud of density 4pts/m2, while modeling of the Central Campus of Warsaw University of Technology was performed based on a cloud density of 12pts/m2. Higher density allows to detect planes of higher probability and also higher accuracy of fitting.

The point cloud obtained from the project ISOK was already classified, therefore only a layer of buildings was used.

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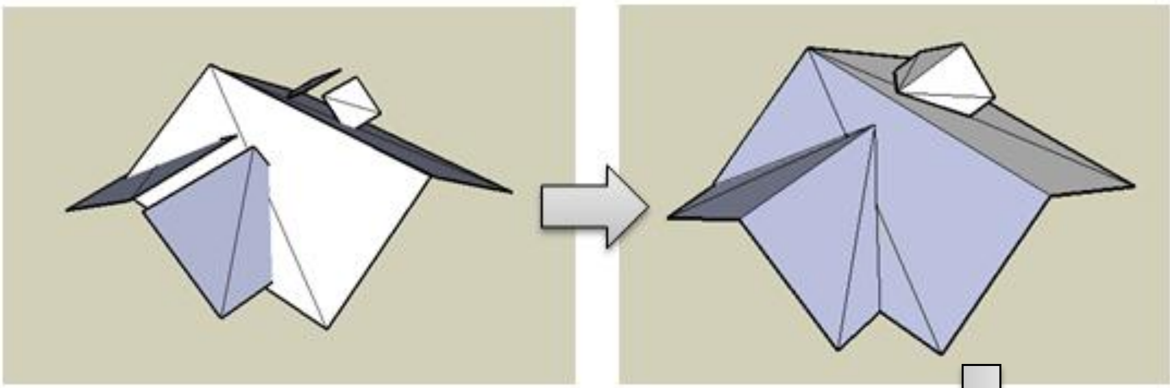
In order to visualize the possibility of the algorithm, SketchUP was used to manually intersect planes. To allow importing from Cloud Compare to SketchUP, planes were preceded to DXF format in ArcGIS which ensures proper georeferencing.



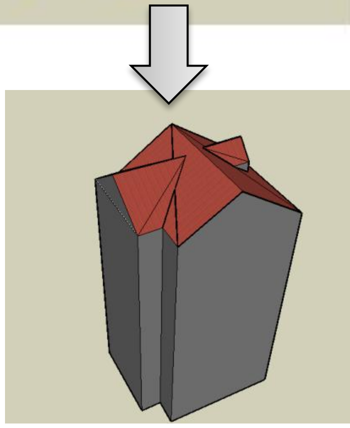


Figure 4: Effects of intersection of planes in SketchUP.

To create complete building model, building outlines at the ground level were taken from BDOT - the topographic objects database. Outline can be also provided directly from the point cloud, but it would be outline of the roof.

Presented method was used in modeling of Central Campus of Warsaw University of Technology. Central Campus has got 17 buildings with very different architectural forms. Ortophoto was used to texturize roofs and digital photos to texturize elevations.

Final effects:

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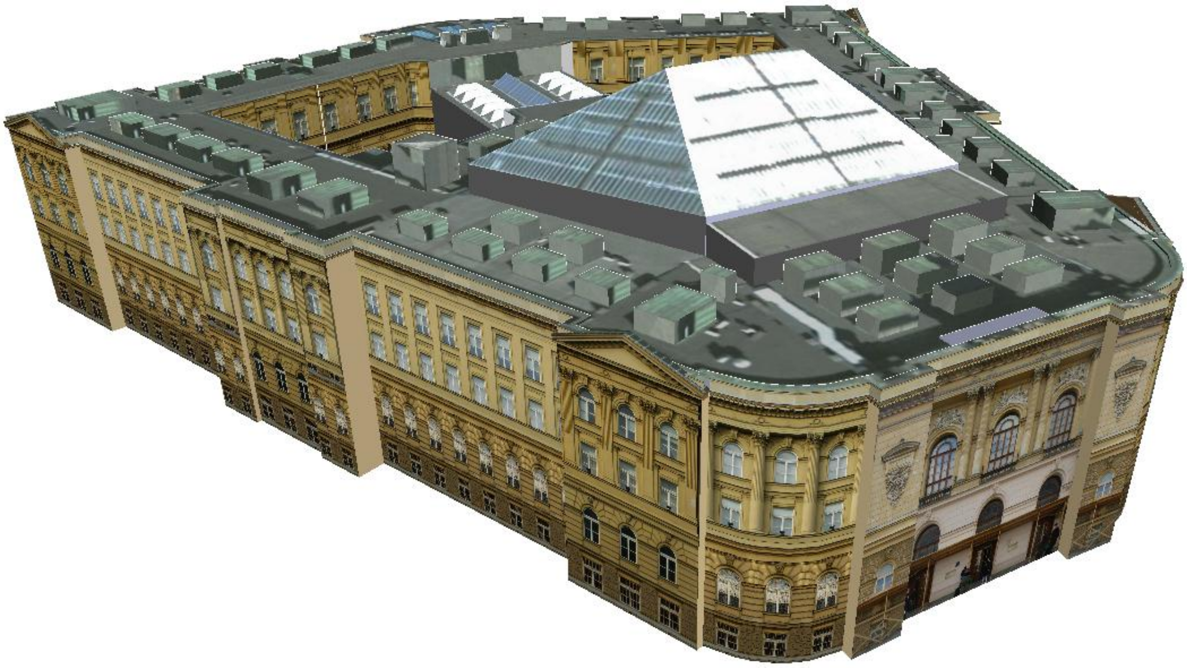

Figure 5: Main Building of the Warsaw University of Technology

Figure 6: Building of the MEL Faculty

CONCLUSIONS

RANSAC algorithm can be successfully used in modelling of buildings based on Airborne Laser Scanning data. Roofs created by presented method could be used in visualizations on Level of Detail 3. Buildings extracted in this project are on Level of Detail 2 because of simply surfaces of elevations.

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