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FROM A POINT CLOUD TO A 3D MODEL – AN EXERCISE FOR USERS OF AUTOCAD AND REVIT

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Abstract. At the Faculty of Civil and Environmental Engineering students learn about various methods of presenting spatial forms - from descriptive geometry to 3D modelling. Both educational and commercial 3D software are continually refined and enriched with ever-improving options, this applies also to commonly used Autodesk products such as AutoCAD or Revit.

One of these novelties supporting building information modelling is the option to work on point clouds that support the design process by providing the actual context. After attaching a point cloud to a model, it can be used as a drawing aid, viewed in a different mode, etc. Considering the fact that the above-mentioned programs are already used by students in early semesters and that they are a basic tool in the office, it is worth using a new tool in a 3D CAD course. The article presents a basic exercise that may prove to be an interesting alternative to a modelling course as it is used to practice basic skills such as rotation, change of reference, etc. In addition, students gain proficiency in transferring data between a few required programs. This task seems to favour the integration of functional skills into several programs but at a fundamental level and can be a great topic for group projects. The task described in this article required the preparation of a point cloud that was obtained using a Leica P30 laser scanner and then pre-processed in Cyclone software.

Keywords: laser scanning, point clouds, 3D modelling, BIM, reverse engineering

1 New technologies for civil engineering – BIM and laser scanners

The current development of new technologies has an observable impact on the workflow of engineer-designer in producing technical documentation. Application of Building Information Modelling (BIM) used for comprehensive digitalisation of an object together with the laser scanning technology results in a shift of the multifaceted tasks of building industry into the digital environment. Laser scanning enables to rapidly capture shapes of objects, building or landscape. Point clouds are processed in different software and are transformed into polygon mesh, triangle mesh, a model CAD, or Nurbs surfaces, depending on the purpose. If the model is to faithfully reproduce physical reality then it tends to be a mesh of uneven surfaces, whereas in the case of building virtual reality with geometric primitives, there is a need for simplification and the associated loss of information appears. In the construction sector the intensive development can be observed in the field of reverse engineering – meaning introduction of existing objects into the digital reality for further processing.

The task is realised with the use of laser scanner which has the advantage of gathering large amount of high quality information in a short time. In construction laser scanners are used for the inventory and assessment of various objects, often historic monuments. Measurements give the ability to discover even minimal deformations, including deflections, horizontal and vertical deformation, changes in time and wetting. As the laser scanning

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technology is becoming broadly used for the inventory and diagnostic works, application of cloud point storage will become a necessity in the engineering practice.

The paper presents an example of a CAD 3D modelling exercise for students in the construction courses. The article presents the analysis of the possibilities of application of selected tools in creation of geometry for the given exercise in various programs. As a consequence of a limited amount of cloud storage for the presented programs, files will have to be appropriately reduced.

2 The aim and method of presented task

The aim of the presented task is to obtain a CAD model of a room together with a window detail based on a given point cloud gathered from the measurement made with Leica P30 laser scanner. The description of the task includes two phases: preparation of the topic by educators and execution of the task by the students (Figure 1). Both phases require usage of different programs, in the phase of executing the task the aim is to use the common, free educational licences of Autodesk products.

The educational aim is to develop skills in spatial operations such as navigating views, rotation, user coordinate system (UCS), real measurements and typical modelling options. Additionally the task requires sending data between the tools and cooperation between students as it is a group project.

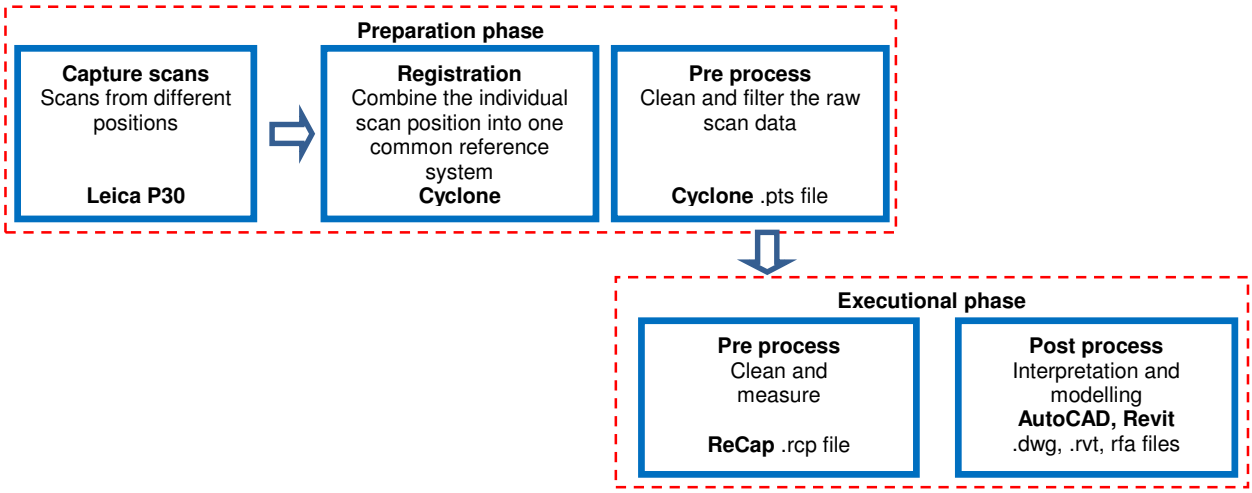

Figure 1: Schematic workflow of the task - phases, software and extension of files

3 Preparation phase of the task

The subject of the task was an educational room at Gdansk University of Technology with an area of about 30 m^2 and characteristic *semicircular* windows (Figure 2).

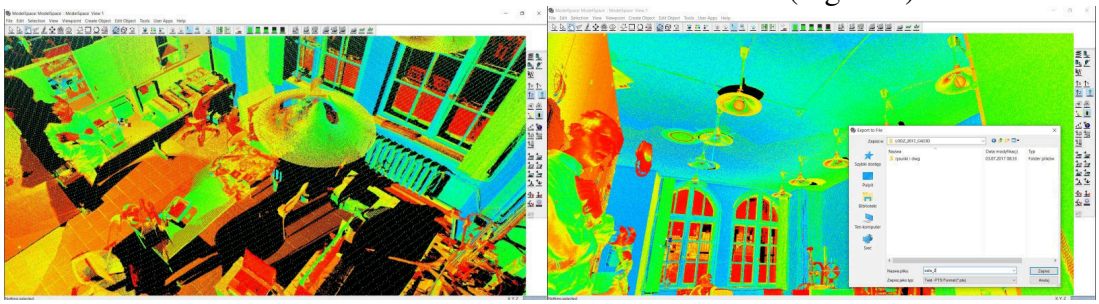

Figure 2: Preparation phase of the task – point cloud registration in Cyclone 9.1, pre-processing, import .pts file

The measurements were made with the Leica P30 scanner form a single location, omitting more advanced geodetic processes resulting from multi-site merging and related errors. The cloud has been loaded and registered, and then reduced, cleared in Cyclone 9.0, with a specialized software for Leica scanners (Figure 2) and exported in .pts file format for further processing by students.

4 Executional phase of the task

The starting point is a point cloud specially prepared in .pts format that includes information about coordinates of points, laser beam reflection and RGB colour. This file can be imported into most point cloud-based CAD platforms, but in our case it has to be processed in ReCap and exported as a .rcp file. ReCap has a very simple, intuitive interface. It allows to change the colour of the clouds, accurately measure the distance between points (Figure 3). Spatial objects can be manipulated in a smooth manner for example clouds may be rotated to get the best views to remove unnecessary noise. ReCap can create planes in the form of regions such as the ceiling, walls, which, for example, can be hidden when removing unnecessary points. However, these planes cannot be read in AutoCAD or Revit without special plug-inns. The program has recently been improved and since the 2017 version it is possible to change the background colour, which is very helpful for the presentation purposes.

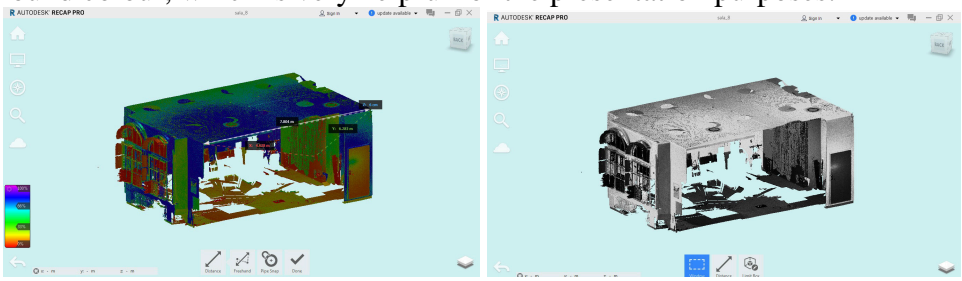

Figure 3: Performing the tasks phase 1 - clearing, measuring elements of cloud, ReCap

In the basic version of AutoCAD it is possible import point clouds, but without additional plug-inns planes cannot be directly generated from the cloud points. In order to obtain the geometry, the point cloud was cut with a horizontal plane and vertical planes, which required the minimum length of a line joining the points and tolerances, the resulting section lines required closure (Figure 4).

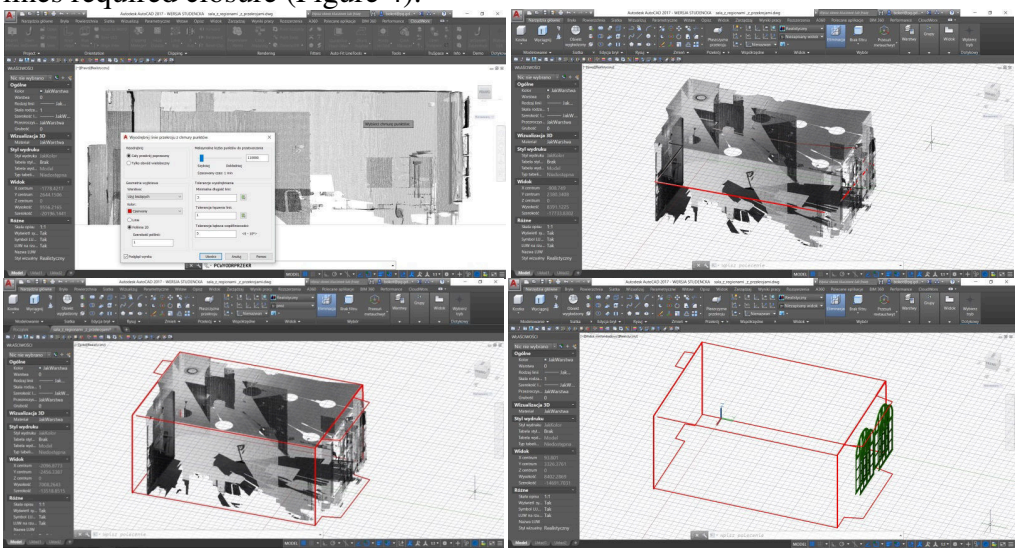

Figure 4: Performing the tasks - horizontal and vertical sections, model of the room, AutoCAD 2017

The part of the task is to prepare a window detail. Typical features such as the height and width of window sashes, mullions and frames have been measured in the ReCap. These sizes are intended to assist in CAD modelling. As with the room model, the window frame was modelled in AutoCAD. In the presented solution this model was used to create a family of windows inserted into the wall in Revit (.rfa file). In Revit, it is possible to similarly load clouds and model, but when creating a family only a CAD model can be loaded (Figure 5).

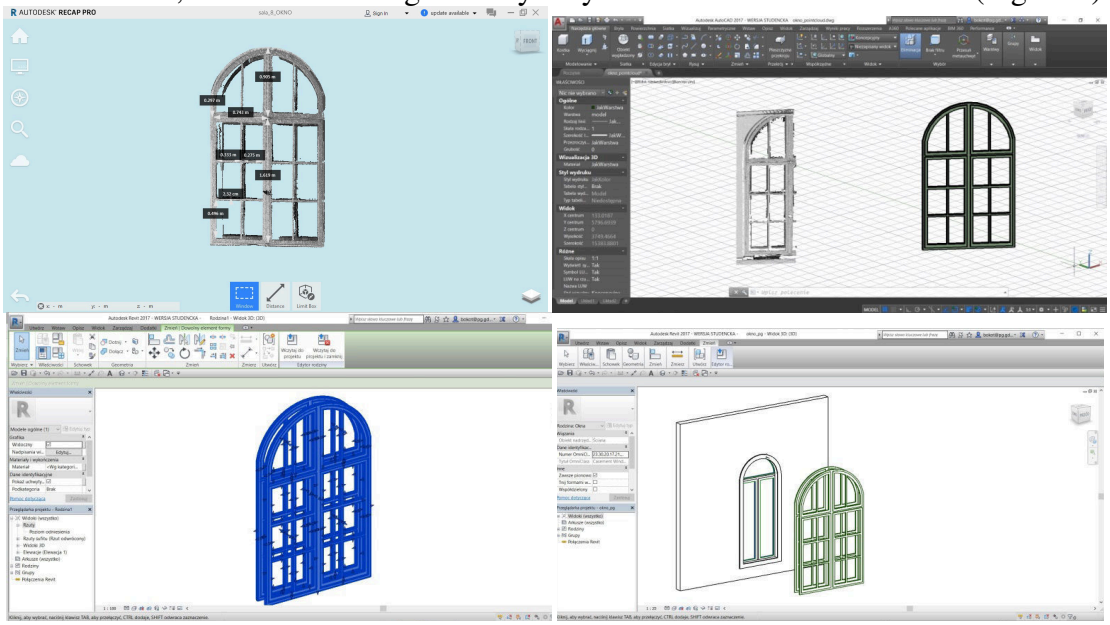

Figure 5: The detail of the window - measurement of the detail, ReCap, 3D modelling from point cloud, AutoCAD, preparation of the window family, Revit

The final wall model was formed in Revit, taking the ground floor and the ceiling height as the lower and upper binding of the outer walls. A door opening was inserted, then the family of the windows was loaded into the project and placed in the appropriate position (Figure 6).

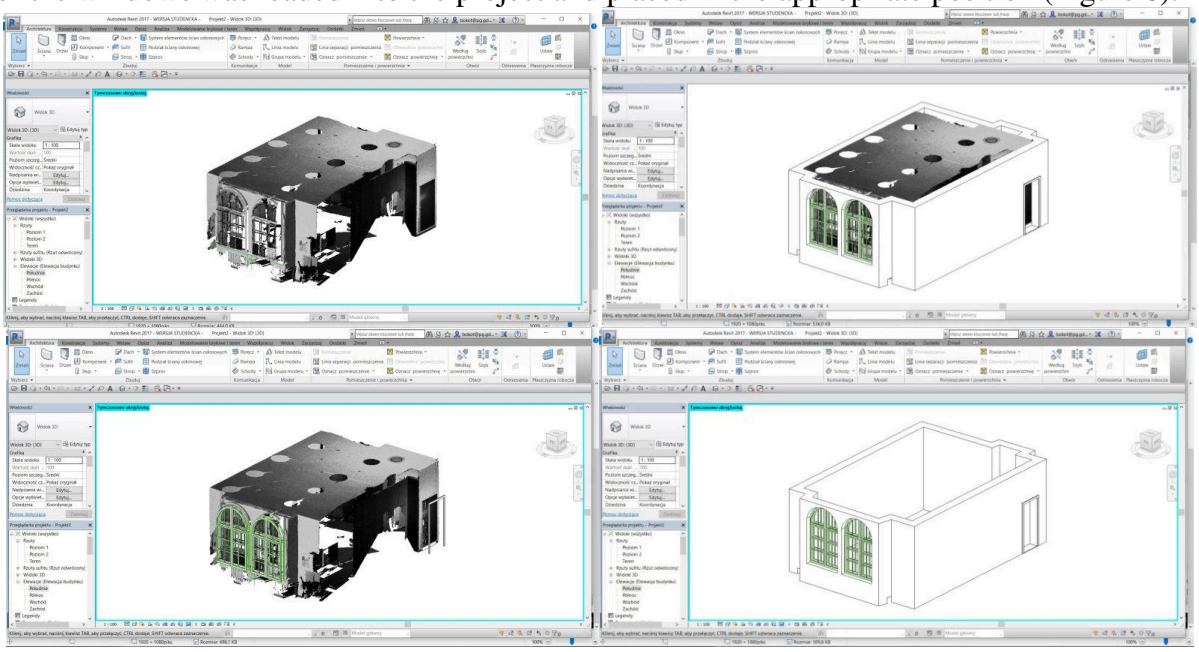

Figure 6: The model of the room, insertion of the window detail, Revit

5 Conclusions

Nowadays scanning technology is becoming more available and the basic programs for civil engineering are equipped with options to work on point clouds. This gives the possibility to create a promising topic for a geometry exercise for civil engineering students. Transforming point clouds into CAD models gives opportunity to develop orientation skills and ability to move in space such as navigate views, rotation, user coordinate system (UCS) etc. The presented exercise was conducted with the use of free programs normally used by students – Revit, AutoCAD and additionally Re Cap. However, the exercise must be carefully prepared as the large point clouds can slow down applications, thus AutoCAD and Revit have limits on the number of points. Moreover, students operate on computers with different parameters.

The task may be an attractive alternative to traditional modelling in space, therefore the author intends to develop the idea by preparing clouds for educational purposes in the near future. It is not possible to obtain more advanced geometric shapes in similar tasks. For this purpose, it is essential to use other applications. Currently, additional plug-ins are available - Pointsense for AutoCAD and Revit and Cloudworx for AutoCAD Clousworx for Revit, but none of them is free at the moment.

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TWORZENIE MODELI 3D Z CHMURY PUNKTÓW

Obecnie można zaobserwować wpływ nowych technologii na zmieniający się warsztat inżyniera projektanta w zakresie wytwarzania dokumentacji technicznej. Rozwój technologii BIM służących do wszechstronnego digitalizowania informacji o obiekcie oraz równolegle skaningu laserowego powoduje, że wieloaspektowe działania w gospodarce budowlanej przenoszą się do środowiska cyfrowego. W wielu krajach, w tym w Polsce potrzebne staje się dostosowanie norm i certyfikatów dotyczących dokumentacji budowlanych, ale kierunek transformacji jest już znany i wraz z nim następuje dostosowanie środowiska edukacyjnego.

W sektorze budownictwa intensywny rozwój można zauważyć w dziedzinie inżynierii odwrotnej czyli wprowadzenia obiektów rzeczywistych do przestrzeni wirtualnej w celu dalszego przetwarzania. Zadanie to może być realizowane za pomocą urządzeń do mierzenia zdalnego, np. za pomocą skanerów laserowych, których zaletą jest zbieranie dużej liczby różnorodnych informacji o wysokiej jakości w bardzo krótkim czasie. Ponieważ technologie skaningu są coraz szerzej wykorzystywane do prac diagnostyczno-inwentaryzacyjnych, dlatego też w praktyce inżynierskiej pojawiać się będzie coraz częściej konieczność działania w chmurach punktów.

W referacie przedstawiono propozycję tematu ćwiczenia dla studentów kierunków budowlanych w ramach zajęć dotyczących modelowania 3D. Zadanie polega na utworzeniu modelu trójwymiarowego na podstawie pomiaru uzyskanego skanerem laserowym Leica P30. Ze względu na maksymalną liczbę punktów w chmurze w prezentowanych programach pliki wyjściowe muszą być odpowiednio wyczyszczone i zmniejszone. Artykuł przedstawia zastosowanie wybranych narzędzi do tworzenia geometrii pod kątem przygotowywanego ćwiczenia w popularnych programach AutoCAD i Revit.