COOPERATION BETWEEN UNIVERSITY AND EXTERNAL COMPANY IN ARCHITECTURAL INVENTORY USING INNOVATIVE MEASURING TECHNOLOGY

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Abstract

Architectural inventories are the main field for using innovative technology (remote sensing). The main purpose of using ie. Laser scanning or photogrammetry is to capture all of the important details of structure. Regarding the extents of inventory works, it may only apply to external details, such as facades, supporting structures and surroundings, whilst in terms of advanced inventory, the building's interior is also expected to be surveyed. The interior works are far more difficult due to complex nature of building's plan. In case of older structures, more historic ones, there are many obstructed places and wall bends that make the survey's geometry situation far more difficult. In this study, the LiDAR technology was implemented considering its look at detail and the whole. Laser scanners are capable of measuring with great spatial resolution giving the operator useful information of both structure placement, together with surface details. No other technology is able to conduct architectural surveys no matter what the light conditions are, giving the opportunity to scan remote, dark basements and attics. This the biggest advantage in comparison to classic photogrammetric surveys conducted with cameras that require proper amount of light. Those pros give operators a chance to complete the works in incomparably shorter time with much higher data quality. A final product of such inventory works are special datasets –"pointclouds" that might be further developed in CAD drawings. Contemporary architectural products combine those CAD outlines into Building Information Models (BIM). What is more, the application of such fast and accurate measuring techniques in service of preserving the cultural heritage sites, endangered by natural disasters or human activity, is worth considering when it comes to possible, unreversable damages. Aforesaid cooperation between industry and university is a perfect match of effectiveness of commercial approach and academic expertise.

Keywords: LiDAR, photogrammetry, architecture inventory, BIM, CAD drawings, geodesy, geomatics

1. INTRODUCTION

Contemporary and complex inventories are the main field for using photogrammetric techniques (remote sensing) in architectural environment; it is hard to imagine the ability to reproduce the amount of details of facades or difficult interior geometry with traditional methods based on ruler, laser rangefinders and sketch boards (Kraszewski, 2012). At present stage of technological progress and actual opportunities for interoperability between surveyor and architect, there is a real employment potential for laser scanning in large and very large projects. This often means a few hundred or over a thousand of scan positions. Then, the unit cost of the scan is the lowest, whilst the practical use of classic measuring techniques seems to be pointless or marginalized due to difficulties with maintaining geometric credibility over large distances and complex shapes. These can result in evident errors during CAD modelling phase. (Kraszewski 2012; Uchański, 2008; Boroń, Rzonca and Wróbel, 2007). The main goal of this paper is to present the results of cooperation between University and external company on the architectural projects. The most common techniques which have been used are photogrammetric techniques, but it has to be mentioned that classic surveying is also useful for inventorying and monitoring tasks utilizing less advanced equipment, such as tachymeter. Considering opportunities of the partnership, the high quality of the data, coming from top quality measuring techniques, meets the expertise from academic staff.

2. LASER SCANNING TECHNOLOGY

Laser scanning technology is based on measurements conducted by light rays, especially laser.. This solution is called LiDAR (Light Detection and Ranging) which is widely used in loads of applications, where huge amount of the data could be acquired in a relatively short time. Concept of gathering the data is established by laser beam pulse measurement. Besides of the information about coordinates of the points, the data of the reflectance is collected. Reflectance describes reflectiveness of the radiant energy echoed from the surface. Major reflectance application is gathering information on material type (bricks, concrete, wood etc.)The application for that option could be used on many fields (for example in saturation level in building materials (Suchocki, Katzwe, 2016). Based on this operation, in post-processing the point cloud could be presented as “false color” view. That gives unfamiliar end-users valuable information on objects' surfaces. Collected information about the coordinates of points results in a possibility to gather complex information about the geometry of the measured object which could be processed to CAD drawings or 3D models. Laser scanning in surveying divides into three major branches: terrestrial, mobile and airborne.

2.1 Terrestrial laser scanning

In Architectural Inventory the most commonly used is terrestrial laser scanning. It is represented by a scanner mount on a tripod.

Fig. 1 Leica C10 laser scanner, placed on the tripod.

Laser scanning technology is able to conduct preparatory works for big and difficult BIM projects No other technology offers the possibility of obtaining such a large amount of data about the architectural object. The results from terrestrial laser scanning applying measuring places with difficult access and complicated structure, for example interior of the church. It has to be mentioned that collecting the laser data requires skillful planning and preparations before data acquisition. Planning the mission contains setting high number of scan positions, due to importance of gathering the whole object's spatial information (do not left any space without measurements), as well as considering the type of surface (i.e. surface covered by pitch do not reflect any pulse).Coming from the experience of the authors, during the planning phase the slide of the laser pulse when the angle between the instrument and the target is high needs to be taken into consideration. Terrestrial Laser Scanning has proved it's usability in collecting data of complex building and structures. Mostly, because there is a possibility to acquire data inside the building, it is the most popular method of measuring with this technique, but it has to be mentioned that the bigger the surface is the more likely the, TLS could be replaced or assisted with Mobile, Airborne Laser Scanning and traditional measurements methods of geodesy and photogrammetry.

2.2 Mobile laser scanning

In architectural inventory, Mobile laser scanning (MLS) has its usefulness when the project requires spatial information about complex of buildings with the high accuracy of the data and where the user is able to save a lot of time in comparison with measuring the whole structure by using the terrestrial laser scanning. Mobile scanner bases its operation on the trajectory. It is referred to as the path of the object's motion in a function of time and it is the starting material for the integrated system of IMU / GNSS (Inertial Measurement Unit / Navigate Global Satellite System), also called as INS (Inertial Navigation System). INS determines speed, position and angle orientation of the unit. Angle orientation is determined by the three- axes gyroscopes and accelerometers described as the values of the angles: roll (transverse swinging), pitch (longitudinal swinging) and yaw (angle, corresponding to the device descent of the course). To set an approximate position of the scanner the GNSS unit is used and it refers to information about XYZ coordinates of the scanner. They are important for the correct execution of coordinate transformations registered by the scanner into the coordinates recorded by the GNSS receiver. In order to transform the coordinates correctly, it is required to measure the distance between the point 0.0 of the receiver (the phase center) and point 0.0 of the scanner (the origin of the scanner) (Janowski et al., 2015).

Fig. 2 Mobile laser scanner (Topcon, IP-53)

In architectural inventory, Mobile Laser Scanning could be used as the primary measurement for further processing, and next filled in by terrestrial laser scanning. It is suitable for the building complex, while driving a car provides a possibility to gather external information about scanned object. The mobile scanning system is able to cover a few square kilometers in one mission campaign presented as point cloud. It's convenient in terms of city-wide scanning campaigns resulting in creating a 3D model of a whole city. In case of this example it is not possible to scan the roofs of the buildings, but this task could be done by using airborne laser scanning. To plan the mission properly the obligation of the user is to determine density of the points in dataset. Density depends on the speed of the vehicle, distance between the target and the instrument scanning rate. Based on these assumptions, the operator needs to georeference roads and places, where the data collection takes place. There is a possibility to increase the accuracy of the data during the poor geometry situation, when the receiver is placed on a vessel (Nowak, 2015). It has to be mentioned that when we placed the instrument on the vessel there is a need to realize about the safety. The sea could be very dangerous, that's why so important is knowledge about its dynamics (Przyborski, 2016).

2.3 Airborne laser scanning

Airborne laser scanning (ALS) bases on scanning system fitted aboard the aircraft (plane, helicopter, gyrocopter). Similar to mobile laser scanning, airborne laser scanning is also based on the trajectory.. There is a constraint about measuring the facades of the building complex but, there is a possibility to acquire vertical data using terrestrial and mobile laser scanning. Using ALS data the user could generate digital terrain model or gather information about the points, placed on the roof. To collect the specified data, the first task for the user is to determine the number of points on the one square meter. The example of the evaluation number shows fig. 3 where the height and speed determine the density of the points according to Riegl specification. Based on that drawing, the speed of the vehicle and the altitude of the flight is set and flight plan is created. It has to be mentioned that in wide understanding of photogrammetry, there is common to use UAV (unmanned aerial vehicle) to gather spatial data with camera or scanner mounted on it. (Burdziakowski, Szulwic, 2016; Burdziakowski et al., 2016).

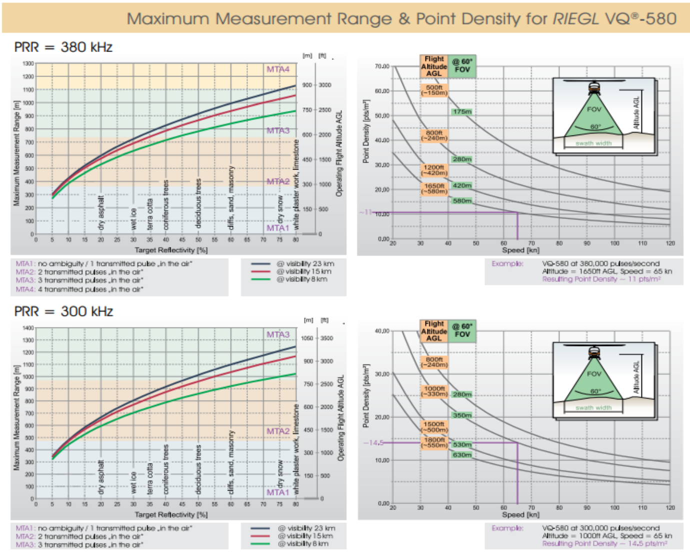

Fig. 3 Diagram presents density of the points related to height and speed of flight, according to the Riegl specification (Website:http://riegl.com)

Fig. 4 Gyroplane, which is used for mapping using Airborne Laser Scanning

3. INTEGRATION OF DATA

Integration of the data from three laser scanning systems is based on plane matching. To create a plane it is needed to define a minimum number of points, maximum plane error and size of the cube where the algorithm has to search planes. The structure of the points is not relevant, because the plane is characterized by a normal vector which originates from the center of the gravity of the found plane. Planes are searched by distance between them and angle in close neighborhood. The example of the integration of the data from three systems are presented in Fig. 5.

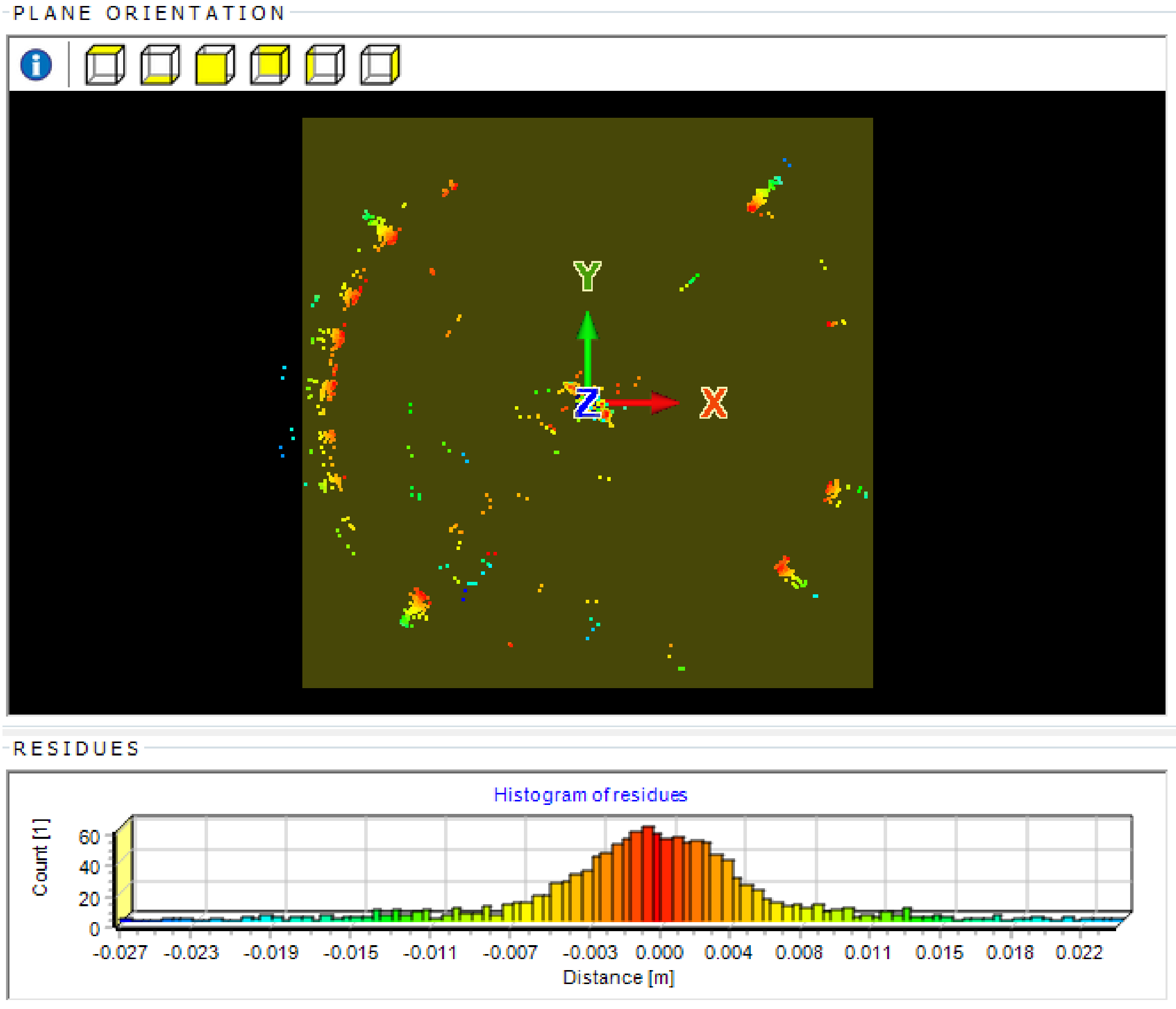

Fig. 5 Plane matching report which presents three scanning system integration

4. BIM IN ARCHITECTURAL INVENTORY

Building Information Modelling (BIM) is a very useful tool in architectural inventory. It has gained important status not only in Poland but in many countries around the World. The most accurate and popular solution to develop digital model of a building is “reality capture” method (Website:http://lidarnews.com). What is more, BIM could be defined as digital model of a complex structures. Through client feedback, companies realized that to manage projects with point clouds created by laser scanning or photographs they require much space on hardware discs and enough computing power that could be problematic for those who want architectural inventory models created by innovative measuring technologies. Another problem that has to be considered is number of the scan positions which have to be aligned in post-proccessing.. It could cumulate the geometric distortion which could effected final created model. That’s why it is very important to combine the experience of the employees in company with scientific approach of researchers at the University. The final products, which is digital models of the buildings are very complex and useful for customers with a minimum

ISBN: 978-605-64453-9-2

influence of errors which depends on quality of processed data.

5. COOPERATION BETWEEN COMPANY AND UNIVERSITY IN ARCHITECTURAL INVENTORY

Most of the projects that have been ordered are very challenging. Besides the final product the technological aspects of the technology are difficult to understand and with such complex projects as architectural inventories there could be a need to create an expertise to validate the collected data. Besides these tasks, there is a need to educate people about this field of measurements to create base of potential clients which are aware of advantages of using innovative measuring technology. The one of the example of the project, which has been accomplished, was creating documentation about the Crane in Motlawa River, in Gdansk, Poland which is listed by the conservation office. The object was very complex and it took more than two hundred scanner positions to acquire detail information about the whole building. Number of scan stations depended on many details inside the structure and narrow passages obstructing the laser swath. Combined point cloud, showed that besides the fact, that Crane was rebuilt after the Second World War, the walls were not straight. Based on that assumption, the quality of acquired model was doubted and it was essential to get independent expertize. The evaluation of the post-processed data based on checking the correctness of the created model. The expertise was made where the standard deviation of the whole model was calculated.

Fig. 5 The front elevation of the crane in Motlata river, Gdansk

The second project, which the authors decided to present was the former complex of Blessed Virgin Mary hospital at Kieturatisa street in Gdansk. An example of the hospital complex demonstrates the possibility of much more rapid data acquisition and shifts the focus from generating very dense point clouds towards fast work progress. Over 1,000 scan positions were registered, with almost 100% use in latter phases. Few hundred rooms of various sizes were covered, including half-flooded cellars and attic, accessible only through narrow hatches. Measurement of the roof surface was conducted with help of lift truck due to the large roof angles and insufficient load-bearing capacity. The complex consists of the main hospital building with 6 floors with historic Uphagen Manor, 4-storey laundry building w historic linen-press, 3-storey boiler house and the newest 4-storey administrative building at the back of the lot. In addition, authors conducted a check on the verticality of the chimney using laser scanning to assess its safe operation and readapting to the new architectural concept. The project was completed in less than 10 days, accompanied with con-current linking and aligning of scan positions. Then, the next three weeks it took to develop the architectural 3D CAD documentation.

Fig. 6 the complex of Blessed Virgin Mary hospital.

6. CONCLUSIONS

Correctness of the processed data influence on the experience for external company and University. Most of the projects are very complex and complicated during the data acquisition and post- processing the data. Cooperation between University and external company in projects, could possible eliminate costful problems. Expertise of done works, which could be presented as the documentation which could be used in case of an argument. It is very valuable, because company is collecting the experience needed to accomplish further projects with success and University is gaining the experience in business-related approach in very complex projects. During the work the authors realized the usefulness of reflectance information, collected by the scanner. The reflectance depends on kind of material but as much as of saturation of building materials (Suchocki, Katzwe, 2016; Suchocki, Rapiński, 2013; Janowski et al., 2016). These characteristics helped to create a 3D model of the structure. Moreover the architectural inventory, the cooperation could be done on many fields. One of the example could be cliff's monitoring (Szulwic, Tysiąc and Wojtowicz, 2016; Burdziakowski et al., 2015; Janowski et al., 2015) where the application of scanning technology could be used (Suchocki, Wasilewski and Aksamitausas, 2008). Sometimes using innovative measuring technologies are not enough for complex projects. It is possible to use different type of the instruments to collect the proper expertise (Kamiński et al., 2015), (Chróścielewski et al., 2014), (Miśkiewicz et al., 2016). Besides the architectural inventory, the University initiate new solution in commercial market to use research in many fields (Błazek et al., 2014; Bobkowska 2016; Bobkowska et al., 2016a; Bobkowska et al., 2016b; Bobkowska, Przyborski and Szulwic, 2015; Bobkowska et al., 2016c; Janowski, Szulwic and Zuk 2015; Mikrut, Kohut, 2016). The future of development the innovative measuring technologies is starting in process of education of the young engineers (Daliga, Przyborski and Szulwic, 2015; Hejmanowska, 2015; Janowski, Jurkowska, 2014; Paszotta, 2015). Students could have a participation in small projects, when they start their career in meaning of using measurement techniques which could help develop cooperation between external companies and university (Laskowski, Szulwic, 2014). Moreover, there is a possibility to use gained knowledge in archeological researches (Szulwic, Ziolkowski, 2016).

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