Preservation and Revitalization of Erdody Castle in Jastrebarsko, Croatia

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3 authors, including:

Luka Babic
University of Zagreb

Almin Đapo
University of Zagreb

PRESERVATION AND REVITALIZATION OF ERDÖDY CASTLE IN JASTREBARSKO, CROATIA

Luka Babić, dipl. ing. geod, Prof. Dr. Boško Pribičević, Doc. Dr. Almin Đapo

University of Zagreb, Faculty of Geodesy, **Croatia**

ABSTRACT

One of Erdödy family estates, a Castle located in the town of Jastrebarsko in Croatia, has immeasurable historical value for Croatia as well as the residents of Jastrebarsko. Unfortunately, the Castle is currently in an extremely ruinous state due to absence of maintenance for a significant amount of time. This was the result of both the changes in proprietary structure as well as the insufficient funding capabilities of the local government. Thus, a cross border project was applied for EU financing by the local government for the purpose of Castle revitalization. A prerequisite to any such project is as always documentation of the current state. The complexity of the object in question and its current state proved to be a significant challenge for conducting adequate survey. The castle is a four winged structure with a courtyard in the centre adorned with arcades and baroque pillars. Out of four of its cone like towers, two remain while the other two are on the foundation level. Beside defensive the Castle had a residential purpose as well. It is surrounded by a moat and continuing on is a beautiful park spreading on 9.47 hectares. It also contains a brook named Reka and a pond named Park. Across from the palace, there is an old granary with a beautiful green patio in front of it.

Due to afore mentioned complexity of the task, laser scanning was the method of choice for conducting surveys. The resulting 124 scans and over 3 billion points speak volumes about the magnitude of the undertaken task. Both the exterior and interior of the object had to be surveyed with sufficient accuracy to ensure the quality of subsequent analysis for other professions involved. The castle has four floors with the first being the basement and the fourth encompassing two rooms of the remaining towers. Those were actually completely inaccessible as no staircase leading to them exists anymore and are too high up to reach using normal ladders for instance. The complete process of survey, and all the challenges encountered on the project will be further elaborated in the paper.

To complement laser scanning conventional surveying techniques were also applied. GPS survey provided the basis while total station survey was implemented for point cloud georeferencing as well as for control surveys facilitating quality analysis. Quality control and quality analysis are integral and indispensable aspects of any survey work but they weigh even heavier in laser scanning projects of this complexity and magnitude.

Keywords: Laser scanning, Cultural heritage, Erdödy Castle, Quality control, Quality analysis

INTRODUCTION

Erdödy Castle (Image 1.) is the oldest preserved cultural heritage monument in Jastrebarsko. It was raised by ban ("Governor") Matija Gereb between 1483 and 1489.

From the beginning of the 16th century up until 1922 the castle was owned by the noble family of Erdödy. This four cornered court emphasized with two impressive, circular towers was an important fort during the Turkish invasion was reconstructed many times in its long history. Internal courtyard (Image 2.), of exquisite acoustics, contains a porch adorned with arcades and baroque pillars. Inscribed plaque (Image 1.), positioned left of the entrance, was placed there in 1592 by a man who was a victor of a famous battle in Croatia "Battle of Sisak" that took place in 1593. He was ban Toma Erdödy, son of the first castle owner ban Petar Erdödy. [1]

Image 1. Erdödy Castle and the inscribed plaque

The Castle is located right next to the centre of Jastrebarsko, and is also surrounded by a beautiful park, and a number of outer buildings along the brook Reka. It was initially a fortress on a plain with design specific to such positioning. Surrounded by a moat, such structures are known as Wasserburgs. During Erdödy' possession of the Castle, it underwent a series of changes and expansions. This resulted in baroque features being added, in addition to its original renaissance features, and its current four cornered design. The only difference to its current condition is that it used to have four towers, two of which still remain, while the other two can only be identified by the remaining foundations.

Image 2. Inner courtyard with arches and pillars

After Erdödy, the estate was bought by Zagreb's wholesaler Ehrman but he soon went under, and thus, the estate found itself on the market and open for public bidding again. Thanks to then current local community' engagement, demolition and conversion of the Castle to construction material was prevented. It instead served as a children's home, municipal museum, even a library for some time, but it also had other functions. Unfortunately, as war broke out in Croatia, care for the Castle was neglected and it started to deteriorate drastically. [2]

The above tells us how much value the Castle has both historically and in significance to the local community. This has been recognized by local government, but the main problem today is allocating funds for restoring such monuments of cultural heritage, and especially of this size. Although the local government is giving a lot of attention to maintaining the property and ensuring that it provides a place of relaxation, enjoyment and pride to the local residents, it cannot ensure much more than that. For that purpose a series of proposals have been drafted and applied for EU funding, each addressing a specific area of interest. The outer buildings have already been restored in such a manner, the park is being refurbished, and, finally, the matter of preserving and restoring the Castle is also being initialized.

Like for any project relating to preservation and/or restoration, documentation of the current state had to be made. This meant conducting a thorough, detailed, and comprehensive survey that will allow identification of all relevant features and details that need to be taken into account in subsequent planning processes. Laser scanning provides an accurate representation of irregular geometric features of objects, and, also, identification of details to small to be captured using conventional methods. One of the main features of the laser scanning technique is to a collect a great data amount and to give a detailed 3D model of the object [3]. Traditional heritage recording methods like terrestrial photogrammetry are not suitable for all kinds of objects. Particularly when the objects have very irregular surfaces and not a clearly defined structure, scanning will probably yield better results than photogrammetry. The main difference between scanning and photogrammetry is obvious: While photogrammetric surveying is an indirect data acquisition method, scanning produces 3D points directly [4]. So, after considering the size, complexity and current state of the object, it was clear that the best survey method for the task was, in fact, laser scanning.

SURVEY

Survey of the Castle was a time consuming process that required good planning and organizational skills, but also a certain level of physical fitness and safety considerations. As the Castle is in such a ruinous state there was always a danger that parts of masonry could fall of, break of under someone's feet, or maybe even completely collapse during the survey, and someone could get hurt or equipment could be damaged. Hence, all motion through the object was somewhat limited and always done in a way that ensures maximal mitigation of safety risks.

Still, one cannot conduct survey without physically accessing certain areas. But even this proved to be challenging. The main issue was the fact that the staircases collapsed, and there is no easy way to access certain areas, which is why ladders were used to get to the topmost levels of the Castle. Unfortunately, even with normal ladders, the highest spaces, located in the towers, could not be reached, as they were too high up (Image 3.).

For those, longer ladders would have to be used, which, in turn, would put a person climbing up, in great risk. Another method would be to utilize a crane or scaffolding, but none of those were available at the time. In the end, there was no choice but to omit those spaces from the survey.

Image 3. Inaccessible spaces on topmost floors of the towers

As stated earlier, careful planning had to be made to ensure that all elements of the object were surveyed, but also, that they were surveyed with sufficient accuracy. To ensure this, sphere positioning with respect to planned scan positions was the key. Also, the scanner of choice for this task was Faro Focus, as it is fast, lightweight, and capable of collecting scans with enough detail to satisfy project needs.

A condition of a minimum of three spheres between any two adjoining scan positions was defined along with one other condition. That other condition was to have spheres visible from both the inside and outside of the building. Considering the final 124 scan positions, inability to conduct a continuous survey (i.e. not having to jump from one section of the object to the other due to accessibility issues), and configuration of the object itself, this required a lot of spheres to have a fixed position during the entire survey. As only 10 spheres were available, this problem had to be addressed in another manner. Fortunately for the laser scanning team, deterioration of the object showed some benefits here, alongside flat horizontal surfaces (Image 4.). Metal beams, and other elements, could be used to place spheres connecting different floor levels, windows, floors, and perches could be used to place spheres between two adjoining scans, etc. Using stickers for marking positions of the spheres, allowed removing, and subsequent repositioning of the spheres in their respective positions. This enabled positioning of the spheres on the outer windows, during the survey of the exterior from the surrounding moat, and those oriented towards the inner courtyard, which had an additional benefit. As all those spheres on windows and perches, oriented toward the courtyard, were captured from one central scan position in the courtyard itself, this provided a certain central fix for all other scans.

Spheres were not positioned only on such surfaces, but also on tripods that were equipped with special adapters. Just like for the spheres, an adapter was used for a small prism that allowed determining global position of sphere centers. This, of course, is done using a total station from previously determined reference points, with known

global coordinates. Georeferencing was done by determining centers of the spheres, positioned on tripods, during the survey from the moat and internal courtyard. In that regard, one could say that scans of indoors were fixed to those of outdoors. As spheres facing the moat and those facing the courtyard are actually on two opposite sides of the object, this was an excellent setting for determining the quality of registration of indoor scans, but that will be covered in the next chapter.

Image 4. Positioning of sphere targets

DATA PROCESSING

Registration of point clouds was done using Faro Scene software, but not all 124 scans were registered as one set. As some sections were, basically, dead ends they were registered as separate sets. The same goes for sections that, due to object deterioration and configuration, required stopping continuous survey at one end, and jumping to another. This is where the idea of placing common sphere targets for the interior and exterior proved the most profitable. Sets registered individually like that, could then be registered to the whole by using, not only spheres connecting them to the rest of the interior, but also the ones to the exterior. Confidence in scans positioned and registered in such a manner was raised to a higher level. The accuracy level of the model could be presented to the investor with greater certainty, and without any restraints.

Table 1. Registration correspondences

Name of set	No. scans	Fitting accuracy (cm)
Scans	36	1.11
Scans1	27	0*
Scans2	11	2.19**
Scans4	13	1.05
Scans5	29	0.75
Scans7	8	0.87

*reference set to which others were registered

**basement area with the highest discrepancy

Registration of individual scans inside each set was, for the most part, achieved within 1-2 mm accuracy (Image 5.), while correspondences between the sets were on a 1 cm level (Table 1.), with one exception. The exception relates to a set of scans of one basement area, with a narrow access corridor, and no other reference matches. For the majority of the object, registration accuracy obtained, provided a very satisfactory result.

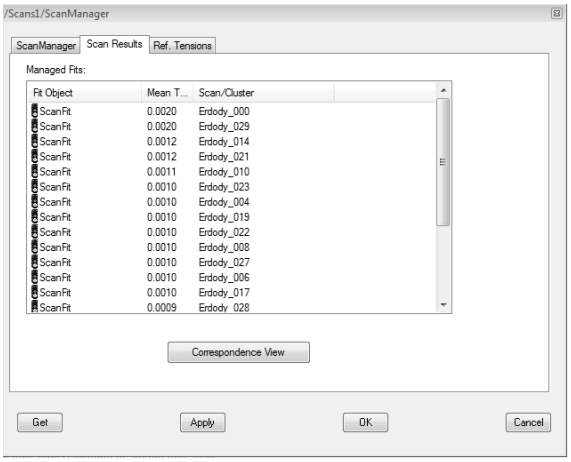

Image 5. Registration of individual scans in a set

DELIVERABLES

As with any project the final result is something that is delivered to the investor. In this phase, those were cross sections, floor plans, and orthographic representations (Image 6.). Total number of points acquired was over three billion which is something any computer has problems dealing with. Even though computers used for processing were all high-end workstation, utilizing 24 to 32 GB of RAM, quad to eight core processors, and good graphic cards with 2 GB RAM, the work had to be divided into smaller sections. It is needless to say that unless 64bit software' are used for point cloud manipulation and data extraction, these kinds of projects are almost impossible to complete.

Before beginning the surveys old floor plans were made available for reference. Comparison of those plans with the results of laser scanning showed some significant discrepancies. This was a result of generalization of previous plans and a lack of adequate tools for precise survey. Final plans and representations provide a reference true to the actual objects shape and features.

Since the project is in the application phase, the above mentioned was enough for now, with a remark that data needs to be ready for other uses, like modeling for restoration design, as a reference for control of restoration works, and so on. Thus, the future use of data will be oriented towards creating a BIM model as a true 3D geometric representation, containing all attribute features necessary for any analysis.

Image 6. Cross section of the basement level

Still, in addition to those, an animation and some perspective views were also made (Image 7.). An animation always makes a project more recognizable and easier to distribute than, for instance, a point cloud. Thus, investors usually find it very useful in promotion of the project. In cultural heritage projects, this can never be emphasized enough.

Image 7. Perspective view of a Castle section

CONCLUSION

Laser scanning for cultural heritage projects has proven its worth many times over, but there is always something new and challenging when approaching the next project. No two projects are ever the same, so a different approach is often necessary for each task. In this project the task involved survey of both the exterior and interior of a very complex object in a ruinous state. Great number of rooms and different spaces required a lot of scan positions, and a good organization of the workflow. Even with that, field work took about six days. One significant reason behind that was the battery life, which was about 4 to 5 hours. The worst thing, which can happen in a scanning project, is to

be stopped before ensuring some fixed reference for continuation of the survey. Thus, a lesson had been learned, and now two batteries are always available.

Sticker markers allowing repositioning of spheres have also been of great help. They not only enabled continuation of survey the next day, but also, they provided a means for making quality analysis (QA) and control (QC) possible. Even though the QA and QC, mentioned in this paper, refer to scan registration, it can be taken as a measure of point cloud accuracy. As the scan distances were rarely greater than 10 m, with the scanners precision being 2mm @ 25m, it is safe to presume that accuracy of feature positions was no les that the overall registration accuracy.

The main issue left to consider is the ease of point cloud data use. Such voluminous data is impossible to handle by weaker computers. On the one hand, development of hardware components may soon make more powerful computers more affordable, while on the other, software producers might bring forth solutions allowing manipulation of such data even on currently standard computers. If the latter happens, it could provide several benefits. Currently, most designers, architects, construction engineers, and others, do not realize the benefit of investing in such expensive hardware equipment necessary for manipulating point clouds, thus making it surveyors' responsibility to extract features we are not always trained to recognize. This is especially problematic in cultural heritage objects. Such a change in software capabilities might, ultimately, be the most beneficial for all parties involved. Either way, it is something that will be known in the future.

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