Open source software application in point cloud processing

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Summary: In the dissertation we're giving an example on the potential of processing data with open source code softwares in relation to the survey of a Roman Catholic monumental church with a laser scanner. During the processing we created models of the building layout and the sections of the church which will hopefully reveal a connection between the length of church walls and interior heights, and fathom units used in feudal Hungary. Furthermore we're pointing the pros and cons of using different data sources.

1. THE CHURCH OF TARNASZENTMÁRIA

One of Hungary's oldest yet still functional churches are in Tarnaszentmária. What is also interesting about it is that according different statements from Hungarian and Czechoslovak historians it is likely that it was built during the Slavic era of our country, from before the Hungarian Conquest with the intent of holding royal burial ceremonies. According to Tibor Gerevich the church must have been built in the middle of the XII. century. However, József Csemegi suggests the nave must have been built sometime during the IX-X. century and is backed by the fact that the building has features originating from Early Christian and Byzantine era.

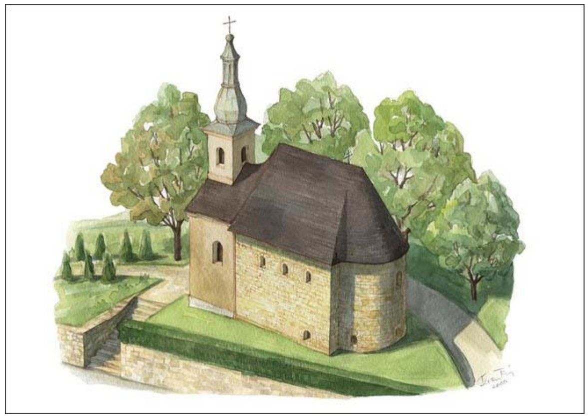

Figure 1. Graphic of the church

Such features are for example the ornate berms at the feet of thin columns. In his opinion "the nave of the church in Tárnaszentmária is the gathering place for the pagan Aba nation, whose ornaments were brought along with our ancestors after their secession from the Khazar Empire." After further archeological discoveries it became clear that the sanctum and the nave were built at the same time. "In the nave of the small church a tomb was discovered with similar features to the building and in its sanctum a "pit-grave" was located keeping the previously disturbed bones of someone who was once important. The latter discovery makes it obvious that the church that means so much to us originally wasn't a gathering place for pagans but it was built as the burial site for a once important family -at least partially, along with serving other functions- before the birth of Roman era architecture in Hungary." As for who built it, either of two people seem likely: Grand Prince Géza and his brother, Mihály.

So the church, just like many other similarly built churches, is suitable to serve as basis to our inspection of the royal fathom.

Figure 2. The church of Tárnaszentmária

2. Survey technologies

We planned on using three different technologies for the survey. UAV, terrestrial photogrammetry, laser scanner, and the traditional measurement using a total station to serve as a basis. By using unmanned aerial vehicle we planned on creating a 3D model and a pointcloud, however the takeoff was foiled by stormy weather, so we were unable to take aerial pictures.

The pictures used for terrestrial photogrammetry were taken by two kinds of digital cameras. The Nikon L340 uses autofocus and takes pictures with 20-megapixel resolution while pictures taken with the Sony Alpha have a 12 megapixel resolution and has a fixed focal length.

Figure 3. Sony Alpha DSLR A350 and Nikon L340

We also used two different laser scanners for terrestrial scanning, a FARO and a LEICA C10 type scanner, the article includes only the data from the LEICA C10 scanner. Measurements with using a total station were made to define the coordinates of control points in a local system.

Figure 4. Surveying using a laserscanner

3. Processing

The processing of laser scanner-based measurements began with the usage of a commercial software called Cyclone by Leica. The evaluations of the data from other surveys were based on the pointcloud resulting from the Cyclone based processing. The software connects pointclouds measured from different stations with 3D congruency transformation. The residual error of the transformation originate from the GCP and -to be more cost-efficient- simple black and white marks printed on paper and are around 1-2mm.

The need for the use of freeware softwares used in education and research in addition to commercial software came up during the processing of laser scanning. We decided with the use of a software called CloudCompare which is used to process and display pointclouds and whose many functions make it suitable for tasks such as this and can be further developed as needed. With the software we are able to join pointclouds with different methods (eg. ICP algorithm, Helmert transformation) Since in our case there's little overlay among measurements made from different stations -to calculate transformation parameters from the co-ordinates of control points- we created an application for its latter function using octave. The program calculates the parameters of rigid body transformation in a way that is compatible with the pointcloud processing software.

With the application coordinates of certain stations can be transformed into a local system defined by measurements using a total station.

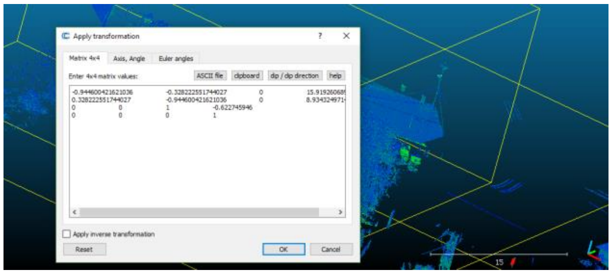

Figure 5. Transformation of each station

The next step was the cleanup of the pointcloud, we manually removed certain points, for example vegetation appearing as noise. The resulting pointcloud only contained points of the church (Figure 6). Using the intersection function of the program sections or the layout of the church can be easily manufactured and exported to any CAD software to serve as basis for any further research concerning royal fathom.

Figure 6. The upper and lower reaches of the church in a single pointcloud

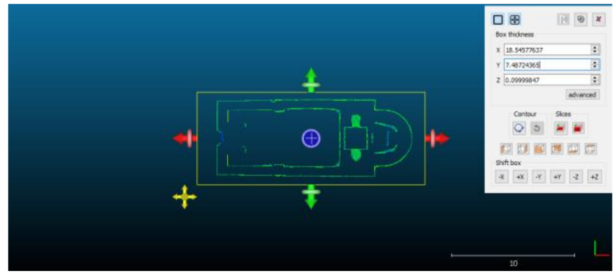

Figure 7. Editing the layout

As mentioned in the introduction the pointclouds weren't only surveyed via laser-scanner but also by terrestrial photogrammetry using non-metric cameras. Our goal was to compare the results of using different technologies from different points of view (difference in cost, time, reliability). During the processing we used a general-purpose commercial software (Photoscan) and later we thought it would be expedient to use other, open source programs. During the evaluation, we chose well identifiable points to serve as control points.

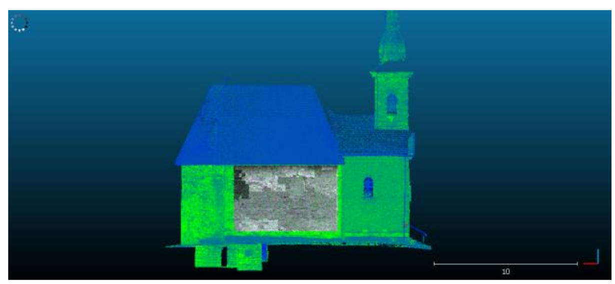

Figure 8. Pointclouds from different sources layered on each other

We designated a sample area to examine the accuracy of the pointcloud created with photogrammetric evaluation (Figure 8.). To compare the two methods we used Cloudcompre's "pointcloud distance" function to calculate the average distance of the laser-scanned pointcloud and the pointcloud resulting photogrammetric evaluation on the sample area with the former serving as reference. The result was ~0.6cm

4. Other Results

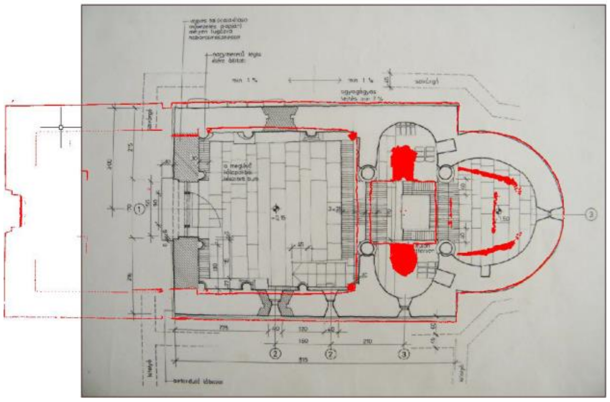

Figure 9. Floor plan in new and old technology

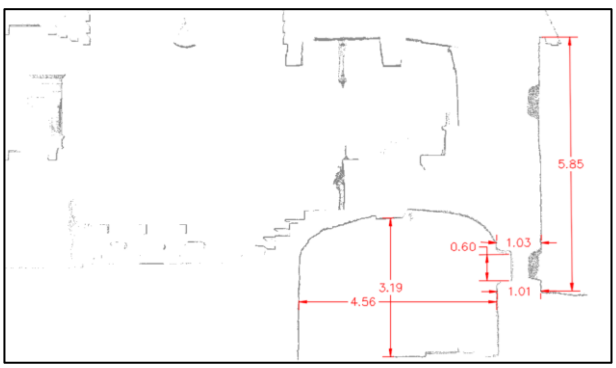

Figure 10. Vertical intersect with sizes

5. Summary

Based on our findings it can be said that both technologies are more than suitable for the architectural survey mentioned in the article. The resulting pointclouds are sufficient to serve as basis for further examinations (creating new layouts, sections or simply measuring length) without any further field survey. By comparing the two the cost-efficiency of photogrammetry is worth mentioning along with almost equally reliable results. As a drawback, it may require additional survey (eg. defining control points).

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