HUNGARIAN ARCHAEOLOGY
E-JOURNAL • 2013 SUMMER
www.hungarianarchaeology.hu

USING 3D SCANNERS IN ARCHAEOLOGY

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Using 3D laser scanners in cultural heritage preservation and archaeology is a universal phenomenon nowadays. Blending potentials of the traditional archaeological techniques and the 3D digital heritage preservation seems inevitable, especially under the current applicable legislation in Hungary for archaeologists working under the pressure of time. In our study we concisely generalize the results of a research and development project.[1]

In English-speaking areas laser scanners are used in the field of preservation of cultural heritage and archaeology in an almost standardized manner.[2] Well-structured recommendations offer an accurate guide both to the customer and business sides. The case studies and analyses on this subject appear in almost unfathomable amounts. We attempt to concisely review, what the SziMe3D project has achieved by now in order to provide the experts with an impression on the potentials of the technologies that are already available in this country, too.

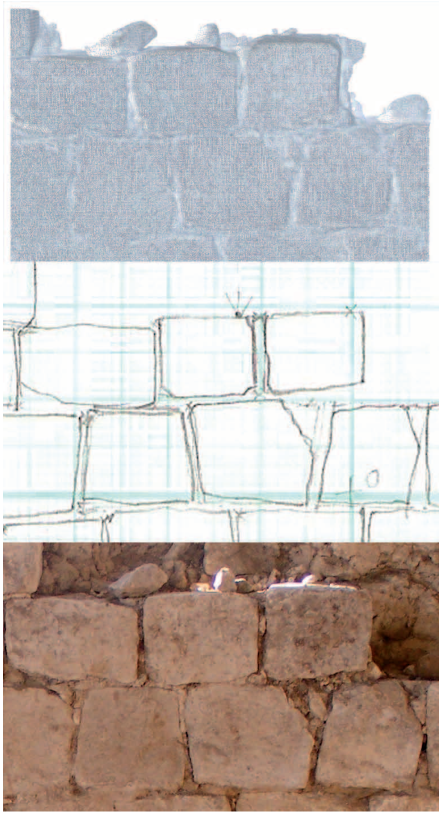

Fig. 1: Medieval wall detail. Up: point cloud (the stones consist of circa 30 thousand points); middle: traditional, drawing documentation; down: photograph.

This technology offers advantages:

- The detailed survey is conducted without direct contact, at a distance with equal or better results than those by direct physical measurement, and no damage is done to the measured object;
- Scanning is particularly suitable for surveying objects with irregular surfaces, such as carved stones, built structures, archaeological features, and they are easily identified in the scanned data;
- Surveying is possible even under poor visibility and low illumination;
- The data are available and can be analysed by the experts at in unchanged but scalable and searchable form at any time;
- 3D models or even complete reconstructions, which can be walked around, rotated and measured in the virtual space, can be created (3D Link1: *Győr, Dunakapu Square, wooden bridge*; 3D Link2: *Reconstruction of the so-called Anjou I. stove from Visegrád*).

[1] SziMe3D – 3D technological innovations in the fields of tourism, education and sports. It is realized in the framework of the project GOP 1.2.1-11-2012-0005 co-financed by the European Union and the Hungarian Government.

[2] Bryan, Paul – Blake, Bill – Bedford, Jon – Barber, David – Mills, Jon – Andrews, David: *Metric Survey Specifications for Cultural Heritage* (English Heritage, 2009). Product code: 51481. http://www.english-heritage.org.uk/publications/metric-survey-specification/metric-survey-specific-for-cultural-heritage.pdf

Fig. 2: Terrestrial laser scanner in operation at the field survey at Dunakapu Square, Győr.

SCANNING TECHNOLOGIES

Terrestrial laser scanners are suitable to documenting archaeological sites and features, ruins as a whole, while the structured light scanners are fit to create models of smaller objects, artefacts with replica level details.

Scanning of buildings, archaeological features

The top-of-art terrestrial laser scanners can scan up to 1 million points in a single second. In practice this capacity is only worth using when surveying the details, because the resulting file's size will be extraordinary large. The density of the recorded points, their measured distance from each other, can vary depending on the task. In our experience we found that for surveying archaeological features the optimal setting is the one, when the points are 3 millimetres away from each other in the point cloud generated by the scanner at the distance of 10 meters measured from the scanner. In this case the optimal distance of the object is about 20 m (the scanner we used had a range of 0.3 m to 187 m). If higher quality is required, it is possible to set the resolution up to 0.6 mm measured also at 10 m from the scanner. However, in such cases it has to be considered that measurement time leaps to hours, the recorded file's size increases drastically, almost to uncontrollable measure.

In most cases the camera built in the scanner does not provide images with sufficient quality and resolution, therefore to create correctly coloured textures we have to take photographs with high quality photographic camera and lens placed exactly matching with the scanner's position. The coupling of terrestrial laser scanner survey data with the National Unified Projection system (EOV)[3] is solved using a GNSS (Global Navigation Satellite System) receiver. The terrestrial laser scanner we use employs a Class I laser unit that does not pose a threat to human health.

Scanning of objects, archaeological artefacts

We usually use devices implementing structured light to survey objects in 3D. These devices are able to scan the items with several tens of microns resolution and with the precision of the one third-quarter of the resolution value. The proper selection of the task-dependent work space (i.e. deciding how big area we can survey at the same time) can be completed with the replacement of lens system.[4]

[3] EOV is the Hungarian acronym for National Unified Projection system, Egységes Országos Vetület
[4] In the Breuckmann SmartScan scanner we use the lens system is variable from 25×20 mm to 1175×975 mm.

Surveying and processing procedure

It is evident that the terrestrial and object scanners are able to survey only what they 'see'. When selecting the appropriate number and location of the measuring positions we do as if we surveyed the measured features with our own eyes. We are searching for points of view, from where every detail, every obscured surface is visible. Careful design of the measurement may seem a lengthy procedure but can prove itself to be quite rewarding in the processing phase.

Any thorough the planning and execution can be, it is impossible to avoid having non-surveyed areas. These 'holes' can be completed then with processing program assisted solutions, tailored to the environment and the available photo shots, and, in most cases, in satisfactory manner. We use target points for terrestrial scanners to join the files recorded from different measuring positions. Previously it was necessary to use such targets for the object scanners as well. The state of the art, colour object scanners we use are able to search themselves reference points based on the shape and texture of the objects and combine the scanned data on their basis. Although surveying from one measurement position may take only a few tens of minutes, the survey of a several hundred square meters large excavation area definitely requires a full day. However, it still takes a lot less time than surveying the excavation with the traditional methods and owing to the fixation of control points, measuring with a total station. Data processing takes twenty times longer than surveying. We can calculate the same way in case of objects as well.

PROCESSING OF SCANNED DATA

We generally use the equipment manufacturer's program to combine (to register) the data files scanned from different measuring positions. From the few billion points generated by the measurements we separate the parts deemed unnecessary (e.g. trees, bushes) and the obviously erroneous points. Due to its enormous size the resulting file is unwieldy yet, therefore, depending on the purpose of the task, we thin further, decimate the file. Nevertheless, we always keep the original measurement file, so we have the option of later modification, correction if the requirements change or error occurs during processing. Traditional 2D drawings can be directly generated from the point file by connecting elemental (discrete) points (vectorisation). Other steps of the whole processing procedure can be followed in *Fig. 3*. The measurement and processing procedures of the terrestrial and object scanner are not significantly different from each other. The object or nature of the subject, the goal to be achieved, and the final product may alter some processing steps, rendering some more important, others less important or even unnecessary. In case of object scanning the planning of measuring is a minor issue while in case of large complex objects direct polygon generation may be impossible due to the large file sizes. Object scanners are capable to immediately generate polygon mesh therefore in such case the decimation step is omitted.

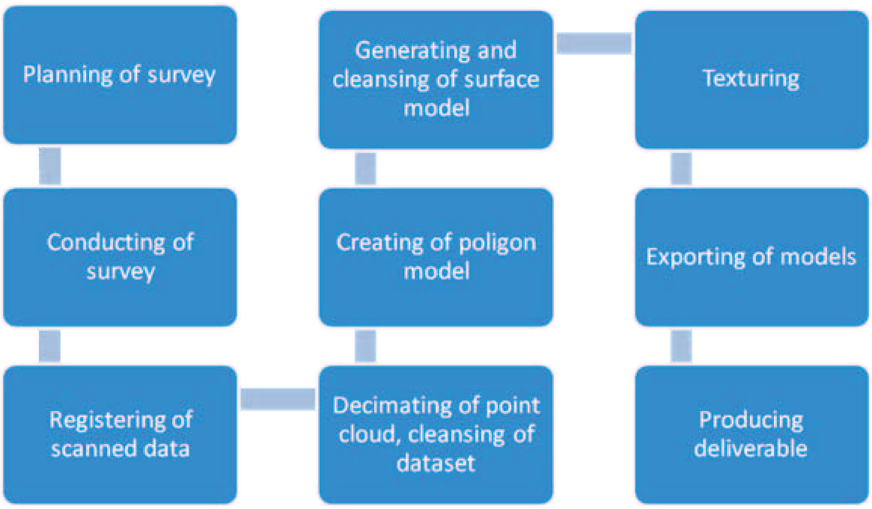

Fig. 3: Steps of surveying and processing

THE YIELDS OF THE WORK

It is important that before doing the survey, archaeologists and survey processing technology experts together determine the goals and scope of the survey, the expected point density and accuracy, the features, tolerances of the drawings to be produced, the requirements for the photographs, the forms of displaying, publishing, the format of the data to be transferred and the deliverables. Today, in the 'learning phase', when the frameworks of these requirements are just taking shape, for the time being we are not quite exactly working that way as described. We generate a data file with maximum accuracy including every possible detail, and from that file we can produce virtually anything the experts of various fields may want.

Clarifying the purpose and intended audience of the survey is essential. Scientific documentation, cultural and educational presentation or publication on the web all demand entirely different solutions. The snapshot-like recording of the exact status of an archaeological feature or as detailed as possible 3D presentation of an object requires surveying with the best measurement parameters. The resulting files that way are manageable only by the latest and fastest computers, with dedicated software. On the contrary, displaying in the web requires sufficiently small-sized, 'dumbed-down' files. It is impossible to equally well serve the two extremes with the same tools. Nowadays we have to resign ourselves to the fact that the hardware used in the survey is a major step ahead of the software available for processing and visualization.

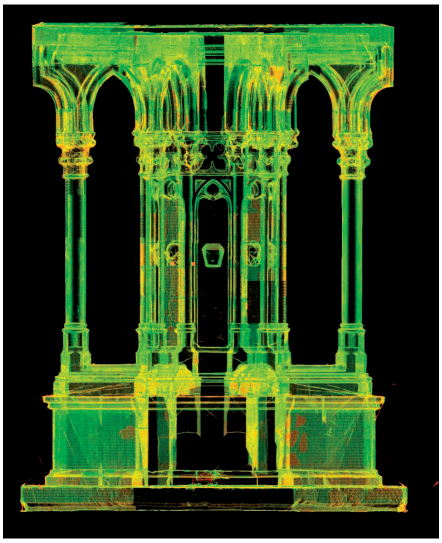

Fig. 4: Well from the age of Louis I in the courtyard of the palace of Visegrád. False-coloured point cloud

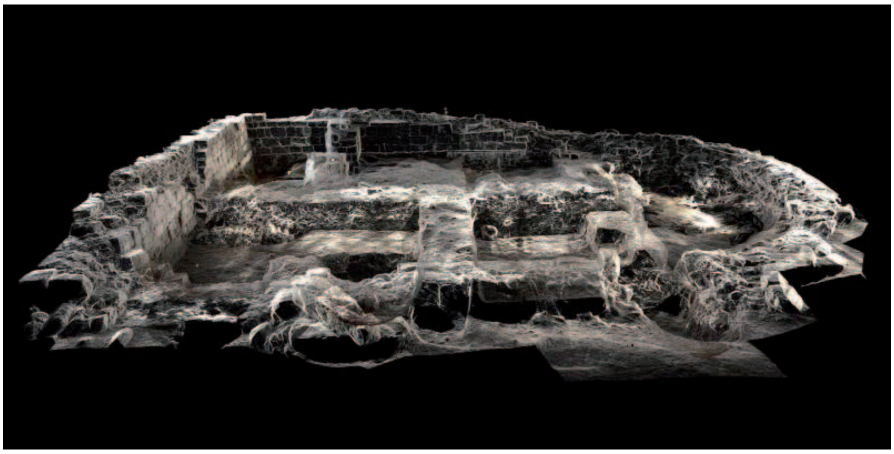

Fig. 5: Ruins of the church at Pomáz-Nagykovácsi-puszta in the process of excavation. In the picture a point cloud is seen consisting of 225 million points, scanned from five positions.

Many people fear that the electronically recorded data may be lost, and because of the frequently-changing data formats, over time they will not be possible to read. The lack of standards, the countless formats used by the manufacturers is also a problem. Nevertheless, there are basic formats, which are not affected by the passage of time, and will be able to be processed at any time (e.g. the ASCII).

Besides the possibilities presented so far there are innumerable other applications worthy of mention, which are available only owing

Fig. 6. Statue representing the Virgin Mary with the Child, Szeged. Object scanning (left), coloured point cloud of the terrestrial scanner (middle), 3D print of the sculpture (right).

to 3D laser technology. From among them, we would single out the 3D printing, with which close to reality replicas of the artefacts can be produced, and thus they can even be 'taken home' with us.[5]

Based on international experience now we can confidently state that the technology we have presented hereby greatly contributes to the accurate documenting, better presentation and generating interest towards our cultural values. However the more accurate and detailed documentation than ever before may not serve as an excuse to dismantle, destroy our cultural values, it is rather a new instrument to preserve and save them.

Recommended literature

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International Journal of Heritage in the Digital Era, ISSN 2047-4970 Multi-Science Publishing

5 For the latest news on 3D printing, see http://www.guardian.co.uk/technology/3d-printing