**Volume 15(2), 52- 56, 2011**
**JOURNAL of Horticulture, Forestry and Biotechnology**

# Using 3D scan architecture

**Băbucă N.I.[1*], Ciolac Valeria[2], Toma C.D.[1], Nistor Eleonora[2], Colțan O.[2]**

[1]S.C. Blacklight S.R.L., Virtutii, no. 1, Timisoara, Romania; Banat University of Agriculture Sciences and Veterinary Medicine, Calea Aradului 119, Timisoara 300645, Romania

*Corresponding author. Email: cristian.babuca@blacklight.ro

**Abstract** Recent developments in differential GPS (DGPS) services have concentrated mainly on the reduction of the number of permanent reference stations required to cover a certain area and the extension of the possible ranges between reference and rover stations. Surveying with GPS has become popular due to the advantages of accuracy, speed, versatility and economy. The techniques employed are completely different however, from those of classical surveying. Provided that certain basic rules are followed GPS surveying is relatively straight forward and will produce good results. From a practical point of view it is probably more important to understand the basic rules for planning, observing and computing GPS surveys rather than to have a detailed theoretical knowledge of the Global Positioning System. A GPS receiver measures the incoming phase of the satellite signals to millimeter precision. However, as the satellite signals propagate through space to earth they pass through and are affected by the atmosphere. The atmosphere consists of the ionosphere and the troposphere. Disturbances in the atmosphere cause degradation in the accuracy of observations. Starting from networked DGPS stations where all stations are linked to a central control station for data correction and modeling, the most advanced technique nowadays is based on the virtual reference station (VRS) network concept. In this case, observation data for a non-existing "virtual" station are generated at the control center and transmitted to the rover. This leads to a significant improvement in positioning accuracy over longer distances compared to conventional DGPS networks.

**Key words**

3D scanning, scanner, modeling, church

The scanning process

3D scanning provides accurate and complete information about scanned objects, which visualize actual field conditions and design in accordance with these conditions, using specialized software. The scanner has the ability to record millions of points obtained on "walk" a laser beam on the object or area concerned (2).

Functionality

The purpose of a 3D scanner is usually to create a point cloud of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject (a process called reconstruction). If color information is collected at each point, then the colors on the surface of the subject can also be determined. Coordinates X, Y, Z of the points made can be imported into CAD programs or 3D as clouds of points (point cloud). Files containing 3D points recorded with a scanner can be viewed three-dimensional analysis as well as 3D models, with the option to measure distances directly on point cloud (8).

3D scanners are very analogous to cameras. Like cameras, they have a cone-like field of view, and like cameras, they can only collect information about surfaces that are not obscured. While a camera collects color information about surfaces within its field of view, 3D scanners collect distance information about surfaces within its field of view. The "picture" produced by a 3D scanner describes the distance to a surface at each point in the picture. If a spherical coordinate system is defined in which the scanner is the origin and the vector out from the front of the scanner is $\varphi=0$ and $\theta=0$, then each point in the picture is associated with a $\varphi$ and $\theta$. Together with distance, which corresponds to the r component, these spherical coordinates fully describe the three dimensional position of each point in the picture, in a local coordinate system relative to the scanner.

For most situations, a single scan will not produce a complete model of the subject. Multiple scans, even hundreds, from many different directions are usually required to obtain information about all sides of the subject. These scans have to be brought in a common reference system, a process that is usually called alignment or registration, and then merged to create a complete model. This whole process, going from the single range map to the whole model, is usually known as the 3D scanning pipeline (7).

Technology

There are a variety of technologies for digitally acquiring the shape of a 3D object. A well established classification divides them into two types: contact and non-contact 3D scanners. Non-contact 3D scanners can be further divided into two main categories, active scanners and passive scanners (3). There are a variety of technologies that fall under each of these categories.

Contact 3D scanners probe the subject through physical touch. A CMM (coordinate measuring machine) is an example of a contact 3D scanner. It is used mostly in manufacturing and can be very precise. The disadvantage of CMMs though, is that it requires contact with the object being scanned. Thus, the act of scanning the object might modify or damage it. This fact is very significant when scanning delicate or valuable objects such as historical artifacts. The other disadvantage of CMMs is that they are relatively slow compared to the other scanning methods (8). Physically moving the arm that the probe is mounted on can be very slow and the fastest CMMs can only operate on a few hundred hertz. In contrast, an optical system like a laser scanner can operate from 10 to 500 kHz.

Other examples are the hand driven touch probes used to digitize clay models in computer animation industry.

Non-contact scanners

Non-contact active scanners emit some kind of radiation or light and detect its reflection in order to probe an object or environment. Possible types of emissions used include light, ultrasound or x-ray.

Category is divided into:

- the time-of-flight: an active scanner that uses laser light to probe the subject (strength: capable of operating over very long distances, on the order of kilometers; weakness: their accuracy)

- the triangulation: an active scanner that uses laser light to probe the environment (triangulation range finders are exactly the opposite of time-of-flight scanners; they have a limited range of some meters, but their accuracy is relatively high)

- Conoscopic holography
- Hand-held laser
- Structured light
- Modulated light
- Volumetric techniques (medical and industrial)

*Non-contact passive scanners* do not emit any kind of radiation themselves, but instead rely on detecting reflected ambient radiation. Most scanners of this type detect visible light because it is a readily available ambient radiation. Other types of radiation, such as infrared could also be used. Passive methods can be very cheap, because in most cases they do not need particular hardware but simple digital cameras.

This category is divided into:

- Stereoscopic systems (usually employ two video cameras, slightly apart, looking at the same scene and the method is based on the same principles driving human stereoscopic vision)

- Photometric systems (usually use a single camera, but take multiple images under varying lighting conditions. These techniques attempt to invert the image formation model in order to recover the surface orientation at each pixel.

- Silhouette techniques use outlines created from a sequence of photographs around a three-dimensional object against a well contrasted background. These silhouettes are extruded and intersected to form the visual hull approximation of the object. With these approaches some concavities of an object (like the interior of a bow) cannot be detected (5).

## Material and Methods

Construction industry and civil engineering:

- Robotic Control: e.g., a laser scanner may function as the "eye" of a robot
- As-built drawings of Bridges, Industrial Plants, and Monuments
- Documentation of historical sites
- Site modeling and lay outing
- Quality control
- Quantity Surveys
- Freeway Redesign
- Establishing a bench mark of pre-existing shape/state in order to detect structural changes resulting from exposure to extreme loadings such as earthquake, vessel/truck impact or fire.
- Create GIS (Geographic information system) maps and Geomatics (5).

Reverse engineering

Reverse engineering of a mechanical component requires a precise digital model of the objects to be reproduced. Rather than a set of points a precise digital model can be represented by a polygon mesh, a set of flat or curved NURBS surfaces, or ideally for mechanical components, CAD solid model. A 3D scanner can be used to digitize free-form or gradually changing shaped components as well as prismatic geometries whereas a coordinate measuring machine is usually used only to determine simple dimensions of a highly prismatic model (4).

These data points are then processed to create a usable digital model, usually using specialized reverse engineering software.

Cultural Heritage

An example of real object replication by means of 3D scanning and 3D printing: there have been many research projects undertaken via the scanning of historical sites and artifacts both for documentation and analysis purposes.

The combined use of 3D scanning and 3D printing technologies allows the replication of real objects without the use of traditional plaster casting techniques that in many cases can be too invasive for being performed on precious or delicate cultural heritage artifacts (7).

Entertainment

3D scanners are used by the entertainment industry to create digital 3D models for both movies and video games. In cases where a real-world equivalent of a model exists, it is much faster to scan the real-world object than to manually create a model using 3D modeling software (6). Frequently, artists sculpt physical models of what they want and scan them into digital form rather than directly creating digital models on a computer.

Crime Scene Investigation

3D scanning allows forensic analysis and modeling information in a shorter time and with less effort than traditional measurement methods.

The model obtained can be exported to specialized software for visualization, interpretation and determination of causes and events that took place.

## Results and Discussions

Historical and Archaeological Background

The Wooden church Stânceşti, the subject of this study, is located in the city Stânceşti (ex Broaşte) of Bihor County, Romania. Is dedicated to "Sf. Ioan Gură de Aur" and is dated from 1752 (Fig.1).

It is of particular interest here is preserved in that part of paintings by “David Zugravul” at the Court of Argeş. In naos (Fig. 3) and the pronaos are kept several fragments of wall paintings and paintings on the iconostasis is believed to have been made around 1756.

The church is declared a historical monument and is located on the new Romanian list of historical monuments under LMI code: BH-II-mB-01206 (Fig. 2).

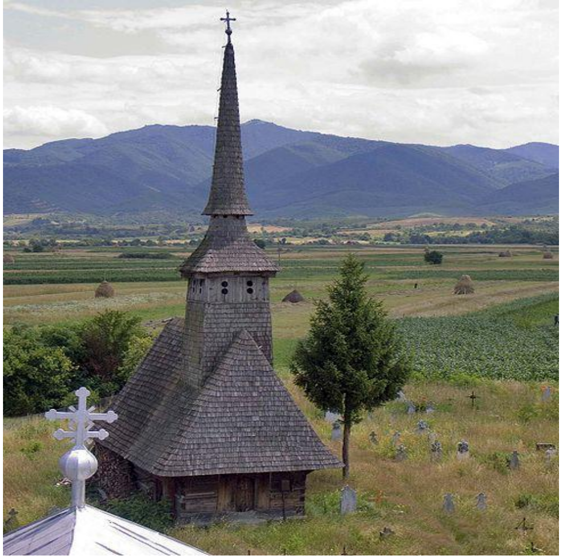

Fig. 1 Stânceşti Church – general overview (2008)

Fig. 2 Stânceşti Church – the entrance (2008)

Fig. 3 Stânceşti Church – the naos interior (2008)

Scanning Methodology

For scanning, it was used a Leica C10 3D Scanner (1).

Leica C10 scanner has the following specifications (main):

- scanning the objective with a speed of 50,000 points per second
- scan accuracy: 1 mm
- scan objective distance of 300 m

Establishing the control network

The methodology typically used for terrestrial 3D scanning revolves around the time-honoured use of prisms or targets. These are typically surveyed using conventional means, such as a Total Station, and then scanned with the laser scanner. Dimensional control is a primary concern when performing 3D imaging in the field. The likelihood of inadvertently introducing systematic errors into the data is very high should dimensional control measures be neglected.

A control network is a collection of identifiable points (visible or inferable) with stated uncertainties in a single coordinate system (Fig. 4). An example of an inferable point is the center of a sphere, while not visible, can be obtained by processing suitable data. A control point may be derived from an object that is permanent or temporary. The purpose of the control network may include: monitoring/controlling data quality (e.g., controlling scale error, removing systematic error), registration, verifying the position of an instrument (drift), defining the extent of a measuring environment.

So, it was and it is necessary to create a control network.

After the control network was created, the scanning process was started: the acquisition of images, targets and control points (Fig. 5, Fig. 6, Fig. 7, Fig. 8), the traverse and the full scanning (Fig. 9, Fig. 10).

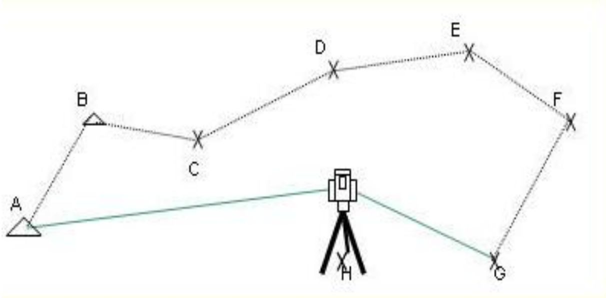


Fig. 4 Example of a traverse with a 3D scanner

Target acquisition and traverse

The five basic steps for performing a field setup are:

- Definitions
- Acquire Back sight
- Known Back sight
- Taking the Main Scan
- Detail Main Scan with Script Editor

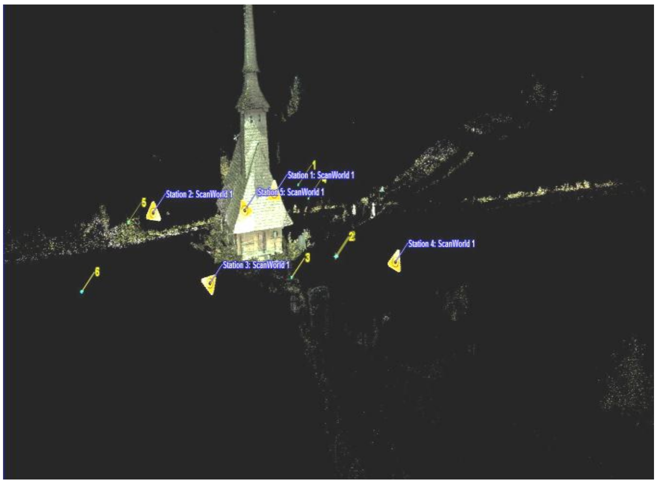

Fig. 5 Stânceşti Church – Site map (targets and control points)

Fig. 6 Stânceşti Church – Site map (targets and control points) Full dome image in True View Mode

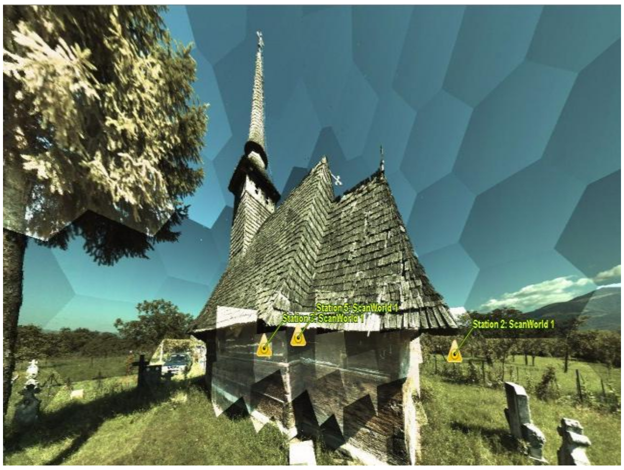


Fig. 7 Stânceşti Church – Site map (targets and control points)


Fig. 8 Stânceşti Church – Inside Site map (targets and control points)

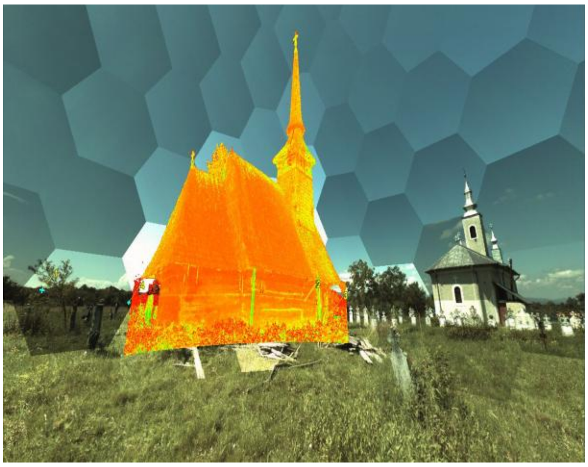

Fig. 9 Stânceşti Church – Outside full scan (1 cm)

Fig. 10 Stânceşti Church – Inside full scan (1mm)

## Conclusions

➢ data recording speed: reduces time and cost

➢ remote recording: increased efficiency and safety of topographic survey

➢ the high density of points provides topographic complexity lift

➢ the possibility to view in real-time of the objective 3D scanned

➢ increase effectiveness working with complex parts and shapes

➢ if CAD models are outdated, a 3D scan will provide an updated version

➢ replacement of missing or older parts

➢ increased accuracy and speed with which calculations are made for plans, elevations, sections, volumes and surfaces

## References


1. Gordon S., Lichti, D., Stewart, M., Tsakiri, M., 2001, Metric Performance of a High- Resolution Laser Scanner Proceedings of SPIE.

2.***Leica Geosystem HDS LLC European Office– Training Manual – HDS and CycloneTraining Triebstrade 14 80993 Munich, Germany;

3. Leick A., 1995, Wiley, John, GPS Satellite Surveying, Second Edition, New York, Chichester, Toronto, Brisbane, Singapore.

4. Schulz T., Ingensand H., Steiner M., 2005, Laser Scanning and Noise Reduction Applied to 3D Road Surface Analysis Proceedings of the FIG Working Week,

5. Schulz T., Ingensand, H., 2004, Influencing Variables, Precision and Accuracy of Terrestrial Laser Scanners INGEO 2004 and FIG Regional Central and Eastern European Conference on Engineering Surveying, Bratislava, Slovakia, November 11-13.

6. Welsch D., 1987, Guide to GPS Positioning – Canadian GPS Association.

7. *** http://www.ancpi.ro, Agenția Națională de Cadastru şi Publicitate Imobiliară;

8. *** http://193.231.4.70:8888 (Stația GPS permanentă Bucureşti);