Journal of KONES Powertrain and Transport, Vol. 21, No. 3 2014

ISSN: 1231-4005
e-ISSN: 2354-0133
ICID: 1132718
DOI: 10.5604/12314005.1132718

NON-CONTACT MEASUREMENT OF GEOMETRICAL PARAMETERS IN LANDING GEAR USING THE HANDHELD 3D LASER SCANNER

Damian Brewczyński

Cracow University of Technology
Faculty of Mechanical Engineering
Institute of Machine Design
Jana Pawła II Av. 37, 31-864 Krakow, Poland
tel.: +48 12 6283406, fax: +48 12 3743360
e-mail: brewczyn@mech.pk.edu.pl

Abstract

Laser 3D scanners are becoming widely used in many industrial branches. They can be used for prototyping, moulds' designs, special tools creation, reverse engineering, quality control. Also in medicine have been used in the generation of digital 3D files body parts or prosthetic. They are also used in diagnostics to analyse the wear of machine parts, deformation analysis of composite structures, creation of digital objects for FEA analysis. The article includes a description of the noncontact method of geometry measurement using handheld 3D laser scanner REVscan based on geometrical measurements of the MIG-29 aircraft landing gear example. During the analysis performed a complete scan of the landing gear with a resolution of 2 mm (accuracy of 0.05 mm) and a scan of critical points with a resolution of 0.2 mm (0.05 mm accuracy). Subsequently, an attempt to determine the position of characteristic points of connections is by editing the resulting cloud of points. During measurements has been shown the advantages, disadvantages and limitations in the use of non-contact method using 3D laser scanners. Collected data was used to find characteristic point of landing gear in main reference system. Two computer programs were used for data processing. First VXelements software is used to calibration, configuration of the scanner and collecting data. Second Geomagic 3D software allows extensive data processing.

Keywords: *Aircraft Engineering, Mechanical Engineering*

1. Introduction

3D scanners are gaining in popularity recently due to ever decreasing cost and availability of 3D printers, which are in set with the scanner, allows rapid prototyping and improving existing structures. In our institute scanner is used mainly for testing composites deformations [1, 2] and manufacturing accuracy. One of the more interesting applications that I could find was to use the scanner REVscan to optimize the position of the Olympic Canoeist in a kayak. Engineers scanned canoeist sitting in the optimum position and then based on the scan files created sitting perfectly matched [3]. This article describes the use of a scanner with the study of objects of larger sizes in field conditions. The object of the research was the main landing gear of Mig-29 aircraft standing outside of the hangar (in the open air). This caused some difficulties because as far as the laptop can be powered from a battery, the scanner requires an external power supply 220 V. In the field, brings the need to use the generator.

2. Scheme of the measurement performance

The measuring system consists of a handheld 3D laser scanner REVscan (Fig. 1) supplied from an external source of 220 V and efficient laptop with VXelements and Geomagic 3D software.

All the progress in scanning and the results will be displayed in real time on the laptop screen. Procedure of measuring:

1) connecting the scanner to the laptop by FireWire cable;

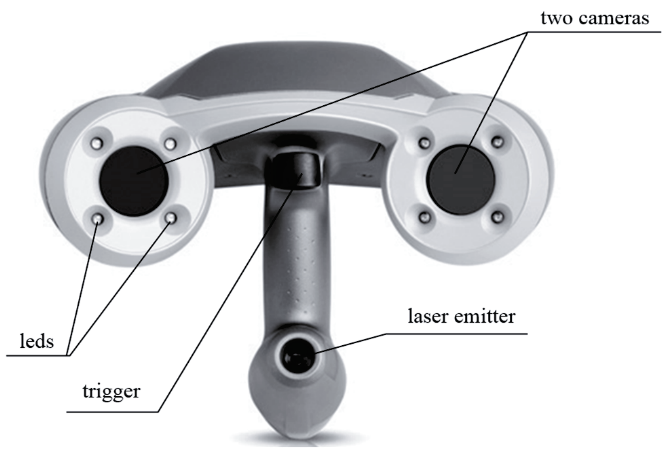

Fig. 1. Handheld 3D laser scanner REVscan

2) connecting an external 220 V power to the scanner (scanner cannot be supplied from a laptop; the main obstacle to the work in the field);
3) running the VXelements program;
4) calibration of the scanner. Used for this attached to the scanner calibration plate, which must be scanned from several directions according to the instructions displayed by the program VXelements on the laptop screen. Calibration is used to eliminate the influence of thermal expansion. The system knows the distance between markers on the calibration plate and the program will automatically calculate the distance from the file scan and during measurements makes the appropriate corrections until next calibration in different temperature. Placing markers on the test object (Fig. 2). Markers must be placed in such a way that the scanner at any time of scanning (distance 150 to 450 mm) saw at least 4 markers placed not collinear. Markers cannot be placed at distances of less than 30 mm from each other. During scanning, it is possible to append additional markers. The program will automatically bind them together;

Fig. 2. Markers placed on the examined object (main landing gear of Mig-29 aircraft)

5) performing the "configuration". It involves adjusting the brightness of the laser beam to a test surface in order to increase the scanning speed. Configurations can be done multiple times during a single scan for example, if we have several surfaces with different degree of reflection;
6) scanning only markers. This is to quickly-check whether the marks are placed in the correct way, and the scanner sees them all. If it is not we must place more markers in such a way to condensate the mesh in areas not visible to the scanner. The program automatically places the reference system at the time when the scanner sees the first 4 markers;

Fig. 3. The scanning process [5]

7) performing a complete scan (Fig. 3). Depending on the size and complexity of the scan of the object can be performed with resolution of 0.2 mm to 2 mm. The software automatically clears the grid of points received on each other so that it does not overlap (this allows later exports to ANSYS Workbench FEA). Two intersecting laser lines are projected onto the object and are observed by two cameras (the distance from the object being scanned should be 150 to 450 mm). The scanner captures up to 18 000 points/s;
8) processing of the measurement file in the VXelements program (Fig. 4). The program allows for example, cleaning points cloud with reflections, filling in the missing pieces adding object. Program allows exporting the file to several programs, among others, ANSYS Workbench, VisualNastran etc.

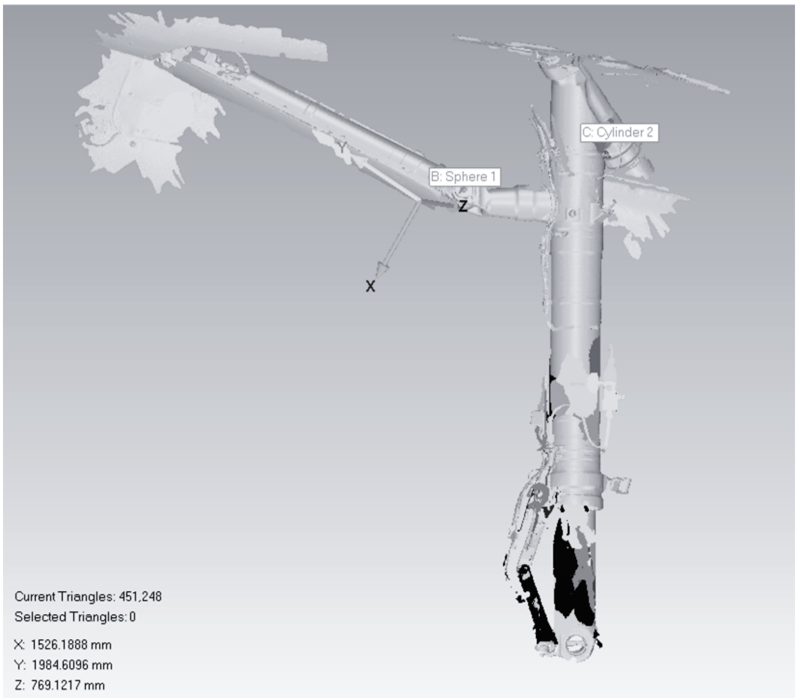

Fig. 4. Scan of the main landing gear with reference system and overall dimensions

3. Identification of geometrical parameters

To identify the main geometrical parameters was used Geomagic 3D software. It allows inserting in a selected group of points geometrical elements such as line, plane, cylinder and sphere. This program also gives the dimensions of the inserted elements and their position in space. This enables finding the axis of rotation, the ball joint centre (Fig. 5a, 5b) in the main reference system.

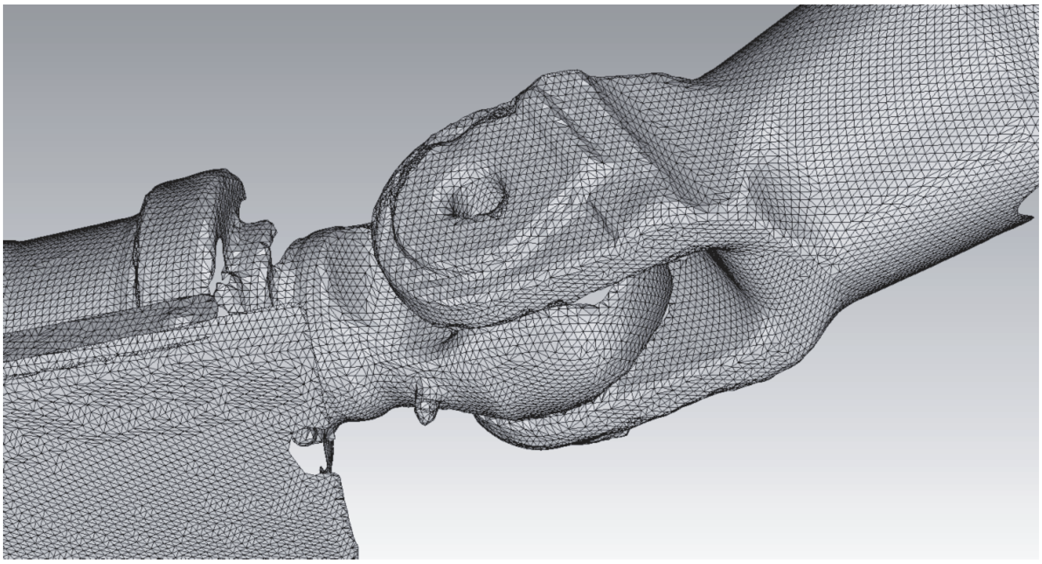

Fig. 5a. Scan of ball joint with a mesh of triangles

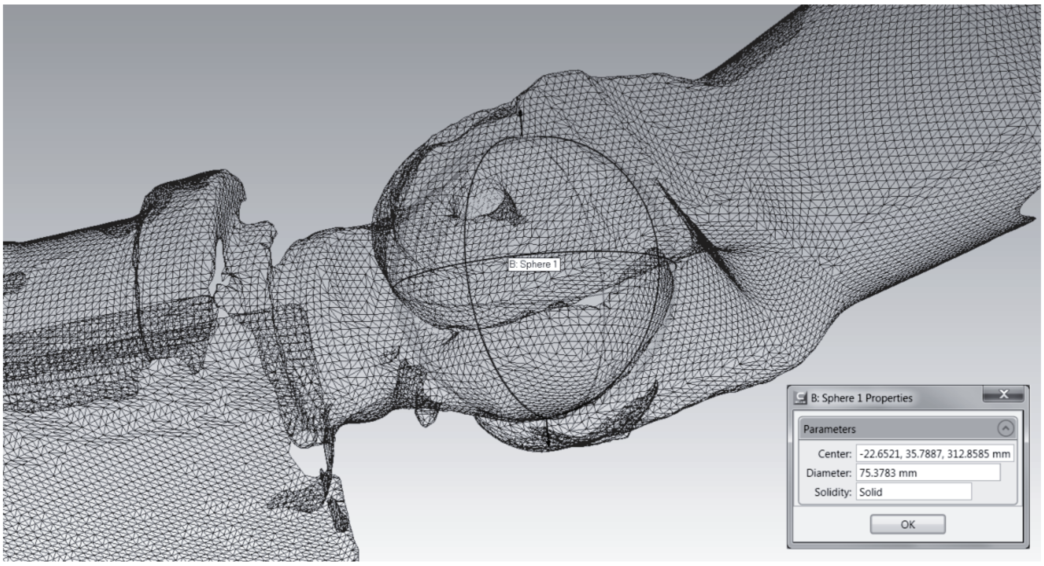

Fig. 5b. Triangle mesh of ball joint with sphere inscribed

4. Limitation in use

Because the scanner uses laser light it cannot scan shiny objects. During the scanning of objects containing even small shiny elements reflections appear. They are visible as suspended in the air non-existent points, which obscures the digital model. The scanner cannot scan the hard to reach areas (Fig. 6a, 6b), which is available using the measuring arm. This is due to the fact that the scanner (Fig. 1) on the bottom has a laser lines emitter. Those laser lines must be visible at all times by the two cameras placed in the upper part. Because of this the scanner is not able e.g. to measure the depth of blind holes.

When scanning small objects with which we want to mapping surface texture or minor faults (Fig. 7a,7b) scanner fails because of the relatively low resolution (0.2 mm). Multiple scans of the same area does not condense measurement grid because the program automatically removes additional mesh points to make it uniform, in this case, this is disadvantage.

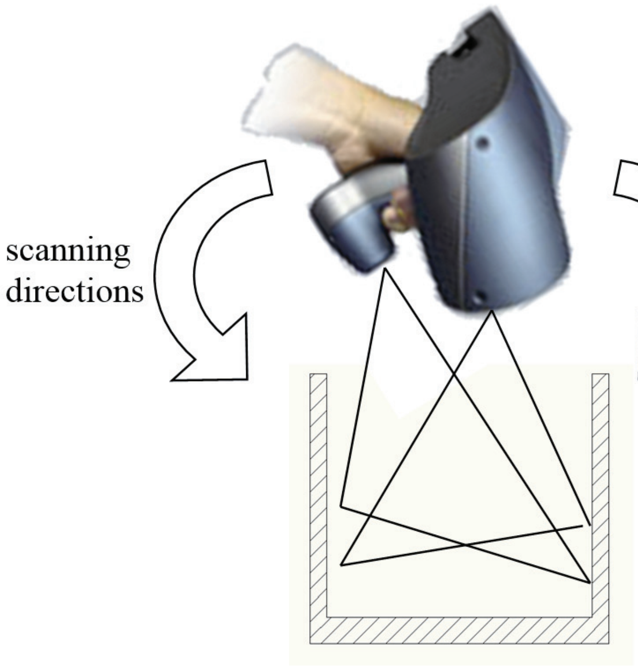

Fig. 6a. Scanning interior and exterior of the profile

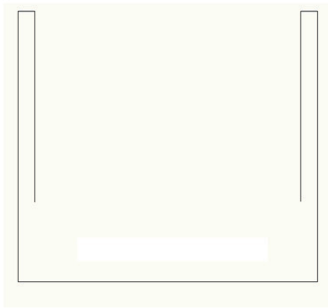

Fig. 6b. Object captured by the scanner

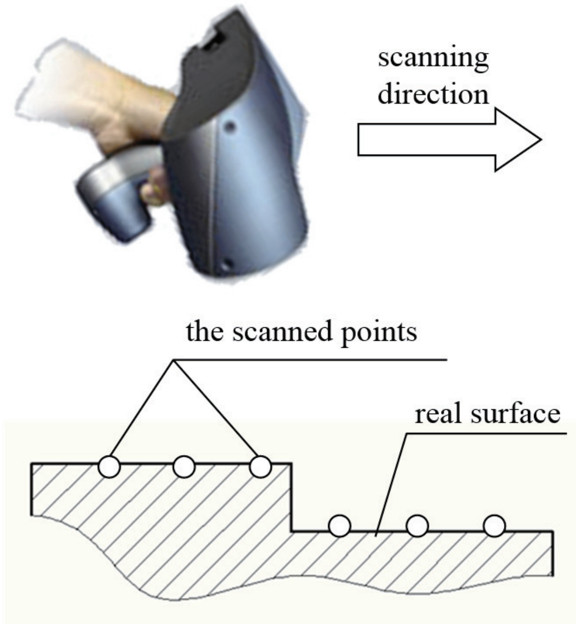

Fig. 7a. Scanning of small imperfections

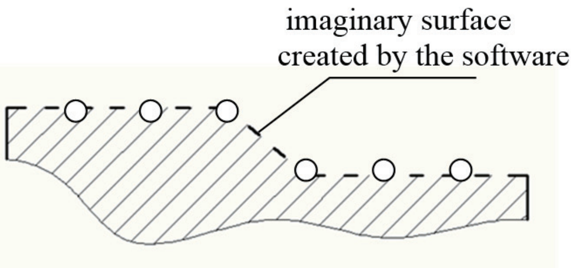

Fig. 7b. Object captured by the scanner

5. Results and conclusions

During the measurements, the 121 markers were used. When scanning in 2 mm resolution, 557,021 points of landing gear were registered. After cleaning 451,248 mesh triangles obtained which can then be exported to the ANSYS Workbench. When scanning only major joints at a resolution of 0.2 mm 4,249,140 points was achieved that gave 3,568,256 triangles.

Use of handheld 3D laser scanner REVscan allowed finding characteristic points of the main landing gears, the rotation axis, the coordinate of the ball joints and the dimensions of the links. The obtained results will be used in future work to create a model that will enable the kinematic analysis of the mechanism movement. It will also be possible to analyse the impact of the accuracy and performance-installation on the mechanism operation.

References

[1] Bondyra, A., Chwał, M., Pastuszak, P. D., *Prospects of laser measuring scanners applications for analysis of the deformation of composite structures*, Processing of plastics, pp. 4-11, 2014.

[2] Bondyra, A., Chwał, M., Pastuszak, P. D., Stawiarski, A., *Analysis of composite structure deformations based on 3d laser scanner measurements*, Composites Theory and Practice, Vol. 1, pp. 38-42, 2014.

[3] http://www.qualitydigest.com/inside/twitter-ed/creaform-and-geomagic-come-aid-australia-s-kayak-team.html.

[4] Lemeš, S., *Validation of numerical simulations by digital scanning of 3D sheet metal objects*, ph.d thesis, University of Ljubljana, Faculty of Mechanical Engineering.

[5] http://www.creaform3d.com

[6] Chen, F., Brown, G. M., Song M., *Overview of three-dimensional shape measurement using optical methods*, Optical Engineering, 39 (1), pp. 10-22, 2000.