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DIGITIZING MEASUREMENT AND SHAPES INSPECTION BY MEANS OF ADVANCED TOPOMETRIC OPTICAL SENSORS (ATOS)

Doc. dr. sc. Branimir Barisic, Mr. sc. Sasa Sladic
Technical Faculty
Vukovarska 58, Rijeka
Croatia

Dr. sc. Mladen Gomercic, director sensor development
GOM mbH
Mittelweg 7-8, Braunschweig
Germany

ABSTRACT
This paper demonstrates the use of new metrology methods (triangulation principle, non-contact 3D digitizing, etc.) for fast measurement and inspection of surface and shape emerged in machining and production. Measurement technique using photogrammetry offers time effective onsite measurement for shape inspection, machining-forming analysis and adjustment work. Paper presents new measuring devices Advanced TOpometric Optical Sensors (ATOS) (for optical 3D digitizing) used in different measuring and inspection processes. This device high performance, enormous resolution and broad selection of additional measuring areas allow for an efficient and precise measurements and inspection. This study will seek to compare the results of these new solutions and traditional method results.
Keywords: metrology, 3D digitizing, inspection

1. INTRODUCTION
In recent years optical-digitizing measuring technologies have been used more and more in the science and industry. New optical digitizing measuring systems could be used for the high-end 3D digitizing, optical 3D deformation analysis, forming analysis, the optical coordinate measuring machines, the precise positioning, motion and deformation calculation, measurement of surface and shapes inspection. Excellent interface to numerical simulation systems and numerical software provides the geometrical informations of the entire shape of parts. Optical-digitizing measuring technologies are mainly used in the first article inspection, assembly control, shape inspection, production monitoring, production process improving. The advantages of these new these new methods are: visualization of the parts in three dimensions and comparison with 3D CAD models or numerical obtained data, the measurement mobility of different places on determined parts, speed up measuring process in relation to traditional measuring systems. Digitizing measurement and shapes inspection of these new systems enables easy-to-understand graphical comparisons between CAD models and as-built parts for first-article inspection, industrial inspection, trend analysis, 2D and 3D geometric dimensioning. The focus of this paper will be on Advanced TOpometric Optical Sensors (ATOS- GOM mbH*)* as optical based 3D scanning systems designed to acquire accurate scan data of three-dimensional objects which goal is digitizing measurement and shapes inspection. These industrial optical measurement systems are used for the highly accurate non-contact measurement of 3D coordinates which measuring techniques achieve exact correspondence between numerical model, real component and experimental results. Traditionally, objects were measured with coordinate measuring machines which collect points from an object by touching its surface. The procedure is quite accurate and reliable, but very slow, inflexible and expensive [1]. Nowdays, 3D digitization with advanced topometric optical sensors taking over a leading position in measuring of complex shape

parts which leads to reduction in the price and particularly more flexibility, accuracy and reliability. By means of these coordinate measuring techniques the exact correspondence between numerical model (IGES, VDA, STEP, Catia format, UG, Pro E format, STL, TXT, ASCII) and real component could be achieved.

2. OPTICAL 3D DIGITIZING

Three-dimensional digitization could be defined as a process of measuring of enormous points number on a part in order to create a digital model of the same part in the numerical 3D form. Advanced Topometric Optical Sensors (ATOS) as optical based 3D scanning systems are designed to acquire scan data of three-dimensional objects and in that way to obtain the goal. These digitizing system are based on the triangulation principle. At the measurement, fringes are projected onto the object surface to be measured and recorded by 2 CCD cameras. From these images the software based on the optical transformation equations calculates the 3D coordinates of over 1 million determined points (figure 1). The current sensor position has been automatically determined by the system and transforms the single measurements into a general coordinate system. In the sensor head of these systems the projection devices and the cameras are mounted. The calibration using the photogrammetric methods of the system has been derived during each measurement, thus ensuring detailed and speed up measuring under the hard industrial conditions. The reference points for the system are targets pointed to the object. By means of the reference points the transformation into the general coordinate system has been done. After scanning, follows the calculating of a complete high-resolution polygon mesh of the object, creating small triangles in curved and large triangles in flatter areas without diminishing the mesh's accuracy. At the end of digitizing a polygon mesh of the object surface has been obtained. Further result processing like mesh editing or reconstruction of surfaces depend on specific tasks and should always be discussed with respect to the actual application [1].

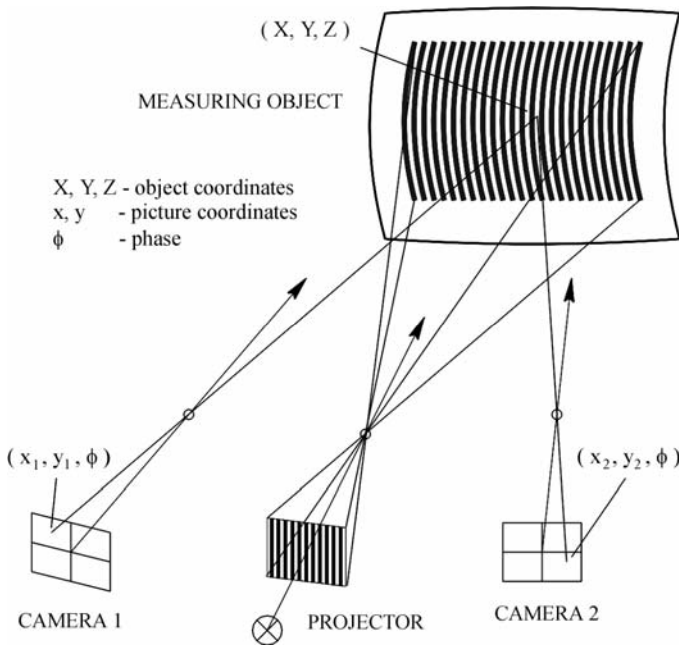

Figure 1. Fringe projection [1]

In this way small as well as large parts (10mm up to 10m) could be digitized with the same sensor. The special type of lenses and the high performance projection system ensure a very dense and highly accurate point cloud with minimum data noise even under harsh environmental conditions [2]. The data gathering for determined area takes some seconds and leads to one million data points, defining the value of the measured area precisely and accurately.

3. EXAMPLE OF OPTICAL 3D DIGITIZING FOR CONTAINER LIDS

The head of ATOS (ATOS III SO, GOM mbH –Braunschweig) is mounted on a stand and positioned in front of the measuring container lids and in that way positioning of sensor have been made (figure 2). After that follows the scanning i.e. projecting different fringe patterns onto the object's surface by means of a white light projection unit and capturing these patterns by 2 CCD cameras at either side of the sensor head. Now, software calculates 3D coordinates of over 4 million container lids points. Finally, the result of measurement is directly displayed (figure 3).

Figure 2. The measuring container lids by ATOS

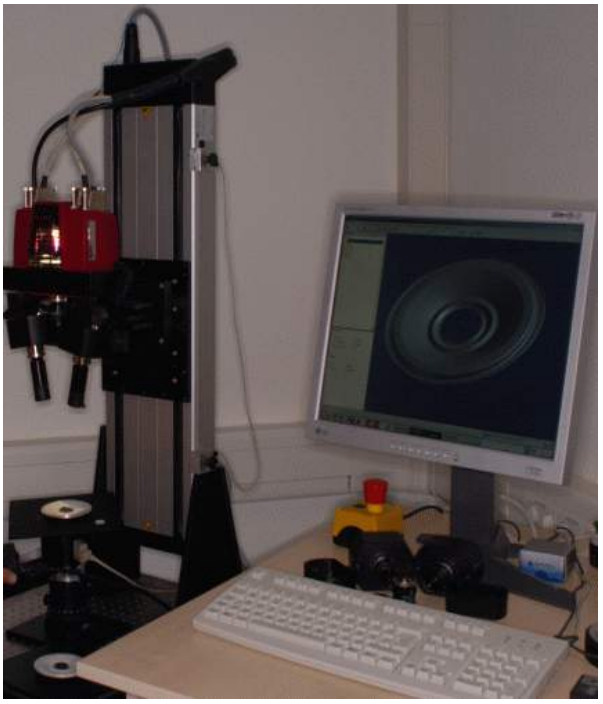

Figure 3. Result of measurement directly displayed

The basic features of ATOS III SO are: high detail resolution and accuracy, a simple measuring concept, the user friendly software, flexibility and mobility.

Figure 3. Directly displayed result of measurement

Presented lid have been scanned segment by segment, where at scanning the area of 35x28 mm have been comprised. Measuring surfaces were covered with titan-oxide powder and referent points were positioned on container lid. Single measurements are automatically matched in one integrality i.e. common coordinate system by means of referent points (white circles on black background). The basic technical features of ATOS III SO are: operation system GOM Linux 7.0, CCD cameras Vox,

2048x2048 pixel camera resolution, Schneider f = 50 mm camera objective, heterodyne coded white light and measuring area 35x28x28 mm, 100x80x80 mm. Measuring conditions are: 22± 0,2^{0}C temperature and 58% ± 10% humidity [3].
In comparison with measurement on coordinate measuring machines at the same measuring conditions (figure 4) the measurement of functional coordinates (plane, circle, slot, line and cone) on displayed lids is maximal speed up and in some cases more than 400 times. At measuring with ATOS 440 000 points could be measured in 8 only sec (50 Hz) [4].

Figure 4. Measuring with coordinate measuring machines

4. CONCLUSION

Digitizing measurement and shapes inspection of Advanced Topometric Optical Sensors enables easy-to-understand graphical comparisons between CAD models and as-built parts for first-article inspection, industrial inspection, trend analysis, 2D and 3D geometric dimensioning. These industrial measurement systems are used for the highly accurate non-contact measurement of 3D coordinates which measuring techniques achieve exact correspondence between numerical model, real component and experimental results. At measuring with these measuring systems 440 000 points could be measured in 8 only sec (50 Hz). Presented example of container lids measurements shows that measurement of functional coordinates (plane, circle, slot, line and cone) in comparison with traditional coordinate measuring machines at the same measuring conditions could be speed up in some cases more than 400 times.

5. REFERENCES

[1] Gomerčić M., Hercigonja S.: 3D Digitization – A Step Toward A Success On The International Market, 4th DAAAM International Conference on Advanced Technologies for Developing Countries, Slavonski Brod, Croatia, 2005.
[2] http://www.1st.com.my/products-gom-atosiii.htm
[3] Barišić B.: Lüders' Bands Phenomenon Analysis In The Process Of Thin-Walled Sheet Products Manufacturing - Ph.D. Thesis, Faculty of Engineering, Rijeka, Croatia, 2005.
[4] http://www.capture3d.com/atos_datasheet.htm