

Methodology for 3D Scanning of Objects

MIGLENA PANEVA, PETER PANEV, NIKOLAY STOIMENOV, STANISLAV GYOSHEV

Institute of Information and Communication Technologies,
Bulgarian Academy of Sciences,
Acad. G. Bonchev St., Block 2, 1113-Sofia,
BULGARIA

Abstract: - In the present work an overview and analysis of 3D scanning, as well as its application in industry, is made. A methodology for 3D scanning of an object using a portable 3D scanner EinScan HX has been compiled. A lifter with a rectangular shape is used for a scanning object. The steps that are performed to visualize a 3D model of the object will be presented in detail. Through the software programs Geomagic Essentials and Solid Edge, its dimensions can be determined and, if necessary, adjusted. The developed model can be used for a standard technology of production or by using 3D printing technology if it allows the use of this type of material.

Key-Words: - 3D scanning, objects, methodology, software, 3D printing, lifters

Received: March 17, 2023. Revised: August 16, 2023. Accepted: September 19, 2023. Published: October 13, 2023.

1 Introduction

Professional 3D Scanning provides a one-stop 3D digital solution - 3D digitization, 3D design to production, and high-end inspection, including 3D data acquisition, 3D CAD design software, and 3D inspection software. Three-dimensional scanning has various applications in reverse engineering (RE), medicine, cultural artifacts, rapid prototyping, quality inspection, industry 4.0, industrial design, textiles, dentistry, and implants, [1], [2]. 3D scanning can help product developers reduce costs and lead times in terms of meeting market demand, customer needs, design change requirements, redesign, reengineering, etc. due to product development cycles that take considerable cost and time through conventional development. The images that are captured by a 3D scanner are analyzed using high-performance computers. The software that is used for image analysis is either built-in for the 3D scanner or others that include SolidWorks, Geomagic Essentials, Solid Edge, etc.

3D scanning is widely used in reverse engineering (RE), [3], [4]. It is used when a physical model of an object is available, but its software counterpart with the necessary parameters for its production is missing. In this way, it is transferred from a real object to a digital object. The 3D scanner collects critical information about the object and a crucial level of detail in terms of size and shape for further processing such as 3D/4D printing, with the fact that additive manufacturing is a potential candidate for Industry 4.0, [5]. The main

functions of reverse engineering are digitization, shape reconstruction, and computer-aided modeling (CAD). A team of scientists has used a method to reduce scanning errors by up to 0.1 %, which can help experts choose appropriate scanning methodology in various fields such as engineering, medicine, textiles, ergonomics, industry 4.0, cultural artifacts, additive manufacturing, and rapid prototyping, [6].

The purpose of the present work is to create a methodology of 3D scanning of objects of different shapes and sizes using a hand-held 3D scanner. Its application will minimize errors in the scanning process, resulting in fast and accurate reproduction of the scanned object, as well as scanning different lifter shapes, as well as scanning of different forms of lifters, as the methodology of the scanning process aims at unification of the obtained data. In this way, a more accurate recognition of shape differences resulting from wear is expected.

2 Application of a 3D Scanning

3D scanning can be used in various areas of life. 3D scanning is very useful in reverse engineering when the user has a physical component that does not have the associated CAD model. Using a 3D scanner can rapidly and easily produce a digital model. 3D scanning can be used to compare the parameters of a CAD model. When items are manually reconstructed and have an original or CAD model drawn, they can be compared to ensure

tolerances meet specifications. The comparison is very useful when scanning 3D-printed bodies to verify the accuracy of the printer. Multiple reports can be generated from the data obtained. Through 3D laser scanning, rapid prototyping of a prototype can be made or sample parts to be created that are handed to reduce production times.

3D scanners are widely used by engineers and metrology experts to determine the dimensions of shapes with simple or complex geometry with sub-millimeter accuracy and high speed. This equipment is preferred over traditional measuring tools, which are slower and more time-consuming, as well as more complex. In this way, quick and effective quality control and design inspection of the manufactured product can be done.

To achieve accurate and fast results and to have greater opportunities for analysis and research of an object, it is necessary to use more advanced software programs:

2.1 Geomagic Essentials

Using standard software alone is not sufficient for the scan-based modeling process. That is why it is necessary to use Geomagic Essentials (Figure 1), which offers the necessary tools for the CAD system. Geomagic Essentials is the link through which the reverse engineering and processing of the 3D scan data takes place.



Fig. 1: Usage of Geomagic Essentials, [7]

The advantages of this software allows direct editing of scanned data and corrects the size of a file for faster processing. The CAD conversion happens automatically with high-quality geometry, which allows being comparison of the design features to scan data for accuracy analysis. The ready CAD model can be converted to a solid format, and imported for 3D printing.

2.2 Solid Edge SHINING 3D Edition

Solid Edge SHINING 3D Edition is a product developed by SHINING 3D and SIEMENS PLM Software. The company is a world leader in industrial software solutions. The created software offers to carry out digital innovations such as reverse engineering, design, and simulation with CAD tools.

The final product is high-quality 3D data for reproduction through "3D Digitization - Design and Simulation - Additive Manufacturing" (Figure 2).



Fig. 2: Workflow of Solid Edge, [7]

3 Used Equipment

For the present work, a hand-held 3D scanner EinScan HX was used (Figure 3), which has an innovative integrated dual blue LED light and blue laser, due to which the adaptability of scanning materials is improved with fewer restrictions for a wider range of applications. EinScan HX has hybrid LED and laser light sources, which allow fast 3D scanning as they are less sensitive to ambient light. Also, the blue line laser scan mode provides better scanning of objects that are dark and reflective. Scanning is fast and within minutes the model is ready for reverse engineering, CAD/CAM, 3D printing, and more. EinScan HX comes with user-friendly software that is easy to operate. The scanner has a built-in color camera that supports full-color capture and texture tracking. The software used to process the scanned object is SHINING 3D, [7].

Specifications:

- Minimum point distance: 0.05 mm. The scanner has an optimal scanning distance that must be respected. If the distance is too close or too far, a red light lights up, which means that the distance needs to be adjusted. At farther distances, the object will not be scanned, and if too close, glare occurs and the scan must start over. Accuracy during laser scanning: up to 0.04 mm;



Fig. 3: 3D scanner EinScan HX, [7]

- Processing speed in fast scan mode: up to 1,200,000 points/sec.

4 3D Scanning Methodology

In the present work, a liner with rectangular lifters is used as an object for scanning. The lifter is used to study the interaction and motion of grinding bodies and the environment in a laboratory ball mill. The overall dimensions of the lifter are an outer diameter of 0,235 m, an inner diameter of 0,228 m, and a length of the lifter of 0,013 m. The lifter is produced from one of the most used 3D additive printing materials – PLA in grey color, [8].

To scan the selected object, it is necessary to go through the following steps:

1. The first step to be taken before proceeding to scan is to calibrate the unit, especially if it has not been used for a long time. If the scanner is not calibrated, it is possible to give not correct output data such as wrong dimensions, and bad scanned surface. The calibration process is made according to the producer's instructions for the device.

2. Another important thing is to place retroreflective markers either on or around the scanned object itself, depending on its size and shape, thus visualizing the scanned object most accurately. The markers give better positioning and feedback for the position of the scanner, as well as better metering results. The scanner manufacturer recommends, [1], that the markers need to be placed at a distance of 2 to 4 cm from each other, avoiding their positioning in a straight line, [9], to be better recognized by the scanner. In this case, the markers are placed around the object, and it is on a black surface so that it can be isolated from the surrounding objects and better highlight the object, Fig. 4.



Fig. 4: Marking the object

3. Launch the SHINING 3D software program and select a scan mode: Scan point cloud or scan markers.

- Set the type of the object: normal, reflective, or black;
- Set the brightness.

4. The laser beam scanning is started, and it is necessary to observe the minimum and maximum distance from the object. For correct orientation, LED indications on the scanner itself glow green, and the SHINING 3D software program serves on the screen. The scanner also has the option to zoom in on the object to scan all hard-to-reach points and folds.

5. The scanned area is cleared of the markers and the pad, as well as any captured surrounding objects, and only the object, is visualized.

6. If necessary, final corrections are made to areas such as auto-filling, when small holes are allowed on the object.

7. The scanned object is saved in the project file.

8. If necessary, the object is turned to the other side and scanned again, following the steps described above.

9. It is again saved in a project, and the two resulting projects are paired with one remaining fixed and the other floated. The alignment can be done in several ways: automatically, manually, and through markers, Figure 5. The alignment of the two scanned sides of the liner with rectangular lifters is done by markers since the object has a section with a hole. The connection points are the beginning and end of the liner.

10. After alignment, mesh data is made to create a 3D model and saved in a convenient supported format: stl, obj, 3mf, xyz, dae, ply, Figure 6.

11. The produced 3D file is imported into the preferred CAD software - Geomagic Essentials or Solid Edge for purposes such as geometry measurement or correction, reverse engineering, and comparison with the original drawings.

12. The ready CAD model could be converted to a solid format and imported for 3D printing.

5 Conclusion

From the overview, it is clear that 3D scanning technology allows a quick method for photographing an existing object in a variety of fields such as engineering, quality inspection, medicine, dentistry, cultural heritage, etc. A methodology has been created that must be followed to scan an object as quickly and accurately as possible. By using the methodology, accurate results will occur, aiming to collect data only from the shape, as well as the wear of the scanned shape of the objects.



Fig. 5: Alignment of the object



Fig. 6: Ready 3D model

The use of a hand-held scanner allows the easy prototyping of plicated-shaped objects (like a used object liner with rectangular lifters), due to the zoom option and the visualization of the scanning process. The device allows scanning of objects of different sizes - from very small to very large, allowing to reach them. The combination of the 3D scanner with the software programs Geomagic Essentials and Solid Edge allows to perform in-depth accuracy analyses on the geometry of the object, to compare with standards and requirements of the original drawings, reverse engineering when spare parts are discontinued and a drawing is needed for its workmanship or a correction is needed in the design and dimensions. Then the ready CAD model could be converted to a solid format and imported for 3D printing.

6 Future Steps

As future steps, it is planned to scan and measure the geometry of the 3D printed lifters used in laboratory ball mills with different lifter shapes to compare with the original drawing aiming to verification the accuracy of the 3D printing. After verifying the dimensions, the different lifter shapes will work in a grinding environment, at the same angle of separation of the laboratory ball mill for a certain duty cycle. Future work aims to analyze the wear resistance of the different lifter shapes. The obtained results will be compared to the obtained results from tribological tests, made with abrasive wear of the used 3D printed materials, [10], [11].

References:

- [1] Shining 3d - High Precision 3D Digitizing Solution Providers - <https://www.shining3d.com/> (Accessed Date: 03.2023)
- [2] Gyoshev S., 3D scanning and 3D printing of artifacts from archaeological excavations to preserve cultural and historical heritage, Proceedings of International Conference "Robotics, Automation and Mechtronics'21", RAM 21, Prof. Marin Drinov Academic Publishing House, 2021, ISSN:1314-4634, p.35-37

- [3] Geng, Z., Bidanda, B., Review of reverse engineering systems—current state of the art, *Virtual Phys. Prototyp.* 2017, 12, p.161–172.
- [4] Pescaru, R., Kyratsis, P., Oancea, G., A Case Study of Reverse Engineering Integrated in an Automated Design Process. *OP Conf.Series Mater. Sci. Eng.*, 2016, 161, 12029.
- [5] Tóth, T., Živčák, J., A comparison of the outputs of 3D scanners. *Procedia Eng.*, 2014, 69, p.393–401.
- [6] Syed Farhan Raza, Muhammad Amjad, Kashif Ishfaq, Shafiq Ahmad, Mali Abdollahian, Effect of Three-Dimensional (3D) Scanning Factors on Minimizing the Scanning Errors Using a White LED Light 3D Scanner, *Applied Sciences*, 2023, 13, 3303 MDPI Journal, <https://doi.org/10.3390/app13053303>,
- [7] EinScan HX - <https://www.einscan.com/einscan-hx/>, (Accessed Date: 03.2023)
- [8] Popov B., Paneva M., Stoimenov N., Klochkov L., Survey and analysis of materials for 3d printing, *XXX International Scientific and Technical Conference*, ADP - 2021., Sozopol, Bulgaria., Publishing house of TU-Sofia ISSN – 2682-9584, Publisher Department “Automation of Discrete Production Engineering”, Mechanical Engineering Faculty, Technical University – Sofia, 2021, pp. 218-221
- [9] Paneva M., Panev P., Karastoyanov D., Stoimenov N., Methodology for 3D scanning and 3d printing of artifacts from archaeological excavations for the preservation of cultural historical heritage, *Proceedings of International Conference "Robotics, Automation and Mechtronics'21"*, RAM 21, Prof. Marin Drinov Academic Publishing House, 2021, ISSN:1314-4634, 38-41
- [10] Kandeveva M., Stoimenov N., Paneva M., Abrasive wear of polymeric composite materials obtained with 3D print technology, Part I Polymeric Materials, *Journal of the Balkan Tribology Association*, Vol. 28, Issue 3, pp. 362-379, 2022, ISSN: 1310-4772
- [11] Kandeveva M., Stoimenov N., Kotseva G., Abrasive wear of polymeric composite materials obtained with 3D print technology, Part II Composite Polymer Materials, *Journal of the Balkan Tribology Association*, Vol. 28, Issue 4, pp. 469-480, 2022, ISSN: 1310-4772

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- Peter Panev and Stanislav Gyoshev carried out the 3D scanning.
- Miglena Paneva and Nikolay Stoimenov are responsible for the 3D scanning methodology.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

This work was partially supported by the Bulgarian Ministry of Education and Science under the National Research Programme “Young scientists and postdoctoral students -2” approved by DCM 206 / 07.04.2022 and by project No KP-06-H47/5 “Research and optimization of the interaction between grinding bodies and media with an innovative shape”, financed by the Bulgarian National Science Fund, and part of the project Grant No BG05M2OP001-1.002-0011 Center of Competence “MIRACle (Mechatronics, Innovation, Robotics, Automation, Clean technologies)”, financed by the Science and Education for Smart Growth Operational Program (2014-2020).

Conflict of Interest

The authors have no conflicts of interest to declare.

Creative Commons Attribution License 4.0 (Attribution 4.0 International, CC BY 4.0)

This article is published under the terms of the Creative Commons Attribution License 4.0 https://creativecommons.org/licenses/by/4.0/deed.en_US