Three Dimension Photogrammetry Scanning system Using Digital Camera

Gafer Abd Alhamid, Khider Tarig, Mohamed Karamalla, and Moaz Ahmed.

Al Neelain University

GCNU Journal

ISSN: 1858-6228

Volume 16 - 2021
Issue: 03

Graduate College
Al Neelain University

Three Dimension Photogrammetry Scanning system Using Digital Camera

Gafer Abd Alhamid, Khider Tarig, Mohamed Karamalla, and Moaz Ahmed.

Production department, College of Engineering, Sudan University of Science and Technology, Khartoum, Sudan.
Corresponding author E-mail: gafergg89@hotmail.com

Abstract

The technology used by the industrial sector determine their ability to competition and continuing, resulting to pursuit suitable tool to fellow the revolution and development, three dimension (3D) scanning is one of effective tool for the industrial sector to implement goals. The three dimension means in the mechanical engineering used complicated and high cost tools. This research purpose to apply scanning photography, which is one of the 3D scanning distinguished comparatively with facility, availability, and less cost. In this research a 3D scanning system has been applied using camera Sony Cyber-Shot DSCW610 and software AGISOFT PHOTO SCAN to construct the model and then SOLIDWORK is used to construct 3D model surfaces. The model in software had been measured and compared with the real value, the error value was± 0.1 mm.

Keywords: 3D scanning; Photogrammetry; Image Acquisition; Build a dense cloud model

Introduction

In reverse engineering a three dimension (3D) scanning systems can be used to build 3D mesh models for the process evaluating an object to better understand how it functions or to have the ability to replicate. The challenge in reverse engineering a physical object lies not only in determining how it was made with little or no knowledge of the original production process but also in accurately determining what its geometry is. The first step in reverse engineering is creating an accurate 3D CAD model of the original object and/or an engineering drawing. 3D scanning is one of the accurate methods for creating 3D digital models, especially for objects with irregular geometry (Kaufman, 2015).

The demand of high precision and quality products is getting higher hence the traditional ways in measuring dimensions in the design and quality inspection processes are no longer sufficient. In addition, 3D scanning can be one of the new technologies that can help to resolve this problem (Pauly, 2003). Five thousand years ago, ancient Babylonians and Egyptians have already used triangulation techniques; Euklid and Archimedes have set the mathematical fundamentals of trigonometry about 2,500 years ago, and Snell von Rojen studied the laws of optical triangulation in the 17^{th} century.

However, practical 3D scanners, based on triangulation techniques, and able to record a 3D picture with sufficient resolution, have been realized only about 25 years ago, after a decade of theoretical approaches, laboratory setups and prototypes based on the latest developments of image processing systems (Guidi, 2012).

With the advent of computers, it was possible to build up a highly complex model, but the problem how to capture that model. So in the eighties, the tool making industry developed a contact probe. At least this enabled a precise model to be created, but it was so slow. The thinking was, if only someone could create a system, which captured the same amount of detail but at higher speed, it will make application more effective (Skaloud, 2006)

In 1996, 3D Scanners took the key technologies of a manually operated arm and a stripe 3D scanner - and combined them in Model Maker. This incredibly fast and flexible system is the world's first Reality Capture System. It produces complex models and it textures those models with color. Color 3D models can now be produced in minutes (Ebrahim, 2015).

3D scanning is used in a variety of fields and academic research. It has benefited clothing, product design, the automotive industry, medical science, record building, especially in places that people may not be able to access due to safety hazards. Also it used in architectural, civil surveying, urban topography, mining, quality, archaeology and dentistry (DRAHNOVSKY, 2004).

Methodology

Photogrammetry scanning technique was executed in three steps:

1- Images acquisition process: measurements by capturing images of an object and then reconstructing 3D models from those images. The camera is positioned at various viewing angles to fully cover each surface of the object.

2- Model reconstruction process: the images consists of a point cloud of geometric samples on the surface of the object. These points can then be used to extrapolate the shape of the object in this step.

3- Surface model creation process: is the method of showing or presenting solid objects.

The figure (1) showed object used for scanning dimensions.

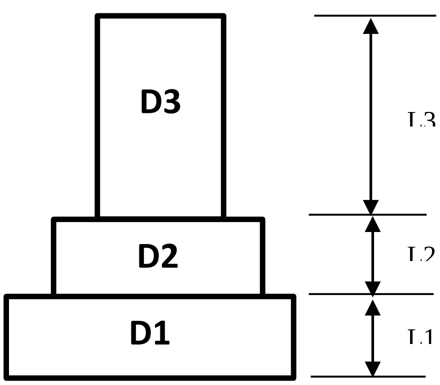


Figure (1): Scanned object part dimensions.

D1=2.35cm, D2=1.90cm, D3=1.60cm, L1=1.10cm, L2=2.00cm, L3=4.30cm

Image Acquisition

The camera Sony Cyber-Shot DSCW610 with field depth of F8, ISO range of (100~3200), shutter speed of the lens (1/1600) second and a 16.1 Megapixel digital single lens (4608x3456 Resolution) is used. The camera was set to exposure mode, fixed zoom, focus, and flash off. The environment is set for capturing process through lighting the subject. Diffused light used to avoid overexposure and to eliminate any shadows that may conceal details of the subject. Background played a key role in the quality of the model as well. The object of interest took up 70% of the frame or more. Photographs overlapped every (5-10) degree.

Model Construction

After the images acquisition process implemented, these images are imported into the 3D scanning software AGISOFT PHOTO SCAN professional in order to generate a 3D model of the scanned body.

Aligning photos: To align the photos and builds sparse point cloud model as shown in figure (2), accuracy is set to high, key point limit value was set to zero, tie-point value was set to zero. (Manual, 2013)

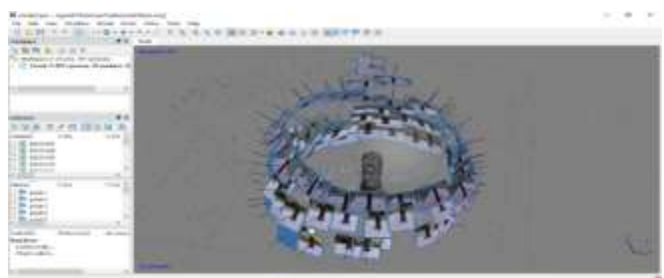


Figure (2): Camera Positions with the Sparse Cloud in the middle.

Build the dense cloud model: To build the dense cloud, quality is set to high, and depth filtering mode was set to middle. (Manual, 2013)

Build the mesh 3D model: Before building a mesh model reconstruction volume bounding box checked to recognize the object of interest from the surroundings as shown in figure (3). (Manual, 2013)

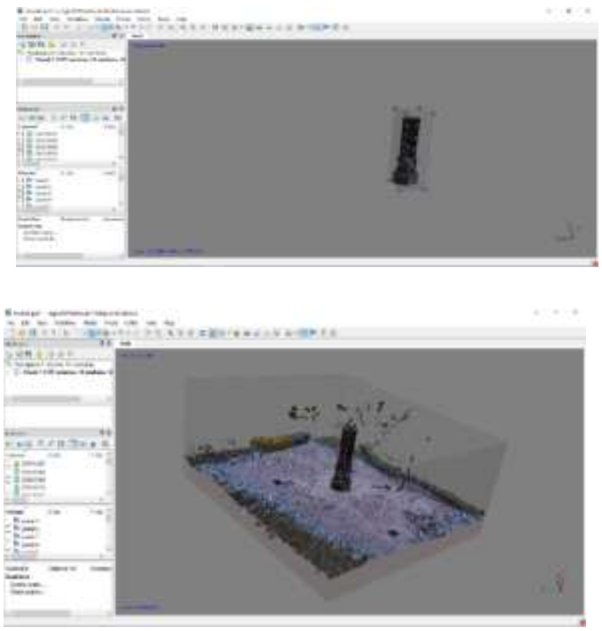
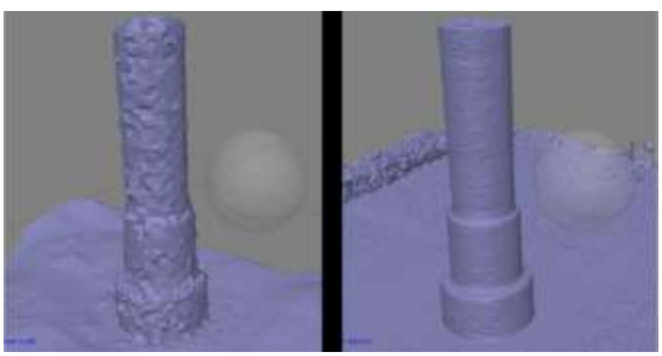


Figure (3): Effect of Bounding Box

To build the 3D mesh model, surface type was set to arbitrary surface, source data can be generated from either the sparse cloud or the dense point cloud. The dense point cloud is chosen because it provides a higher face count range, which leads to a higher quality mesh model as shown in figure (4). (Manual, 2013).



(a) (b)

Figure (4): Mesh Models with different Source Data
(a) A Mesh Model generated from a sparse point cloud with a medium face count of 30,000.
(b) A Mesh Model generated from a dense point cloud with a medium face count of 599,723**.**

Face counted parameters specified the maximum number of polygons in the final mesh. A suggested values (High, Medium, and Low) are calculated based on the number of points in the previously generated. (Manual, 2013)

Surface model construction: To create a surface model a CAD software, SOLIDWORKS, used to provide the ability to modify or manipulate the features of a model as shown in figure (5).

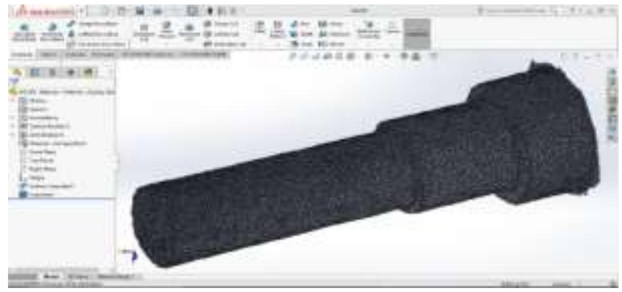


Figure (5): Surface Body Model

Results and discussions:

3D scanning photogrammetry scanning technique is used, acquired mesh shown in figure (6), and a statistics data are presented in table (1).

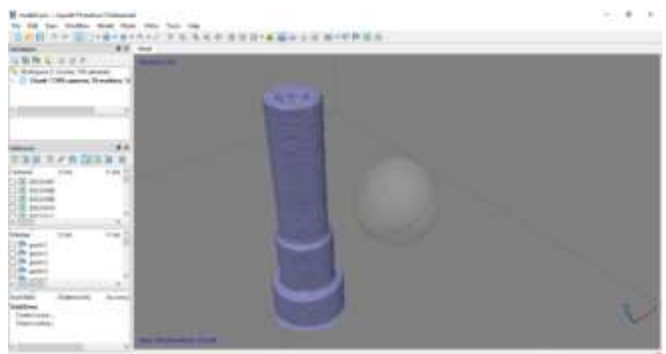


Figure (6): Mesh Model.

Table (1): Mesh Statistics for Object Model

Property	**Value**
Total Faces	397680
Total Vertices	199046
Out of Range Indices	0
Degenerated Faces	6
Connected Components	3

After acquiring the mesh model, some measurements were implemented and presented in table 2.

Table (2): Volumetric and Arial Measurements of Object Model

Measurement	**Value**
Area (cm^2)	117.054
Volume (cm^3)	83.753

The acquired model had slightly different dimensions. The real object dimensions and model dimensions are presented in table (3).

Table (3): object dimensions and model dimensions

Dimension	Real-World Object	3D Model	Error
L1	11.00 mm	11.00 mm	0.000
L2	20.00 mm	19.943 mm	0.060
L3	43.00 mm	42.954 mm	0.046
D1	23.50 mm	23.583 mm	0.083
D2	19.00 mm	18.921 mm	0.079
D3	16.00 mm	16.108 mm	0.108

The model acquired showed a good level of detail and geometry with an acceptable surface error. Which shows the photogrammetry 3D scanning high capabilities and good accuracy of 3D scanning techniques.

Several measurements implemented in the model, the average dimensions error from real object was ± (0.1mm). These results found without fully utilize the maximum potentials of the software, when setting the process parameters to the highest quality. Because of long time needed due to the low capabilities of computer used.

Conclusion:

The importance of using a 3D scanner lies in that it can get accurate measurements for complex items in a convenient period thus simplifying the design stage, speeding up prototyping and quality control processes. The 3D scanner was created by reconciliation between the camera, model construction software (AGISOFT) and CAD software (SOLIDWORKS) to build a 3D model with various applications. All of the components of the photogrammetry 3D scanning system are available and cheap compared to other scanning systems that are the only cost needed is to purchase the camera, In this research, the camera cost was 40$ and all used software is free online. The 3D scanning system was implemented successfully and a 3D model was obtained. The model acquired show an average error of ± (0.1mm) which was encouraging referring to the whole process simplicity. The photogrammetry methods can be powerful alternative techniques in the CAD model reconstruction of small real objects by improving the design process with a small error considering that it takes less time than designing the model from scratch thus improving the industrial and manufacturing processes. The typical reverse engineering process involves an expensive slow process for the 3D model acquisition and shapes reconstruction. Photogrammetry is one of the easiest ways of obtaining dimensional information of complex parts with high irregularities.

References

DRAHNOVSKY, J., 2004. Maintenance orgnisation by the system TPM. *proceeding of 6th international doctoral conferance*, p. 320.

Ebrahim, M., 2015. 3D laser scanners’ techniques overview. *Int J Sci Res,* 4(10), pp. 323-331.

Guidi, G. a. R., 2012. Modeling and simulation in engineering. *3D Modelling from real data,* pp. 69-102.

Kaufman, J. C. M. a. R. A., 2015. Reverse engineering using close range photogrammetry for additive manufactured reproduction of Egyptian artifacts and other objets d'art. *Journal of Computing and Information Science in Engineering,* 15(1).

Manual, A. P. U., 2013. *Profesional Editor,* Volume 1, pp. 2-16.

Pauly, M. K. R. K. L. a. G. M., 2003. Shape modeling with point-sampled geometry. *ACM Transactions on Graphics,* July, 22(3), pp. 641-650.

Skaloud, J. a. L. D., 2006. Rigorous approach to bore-sight self-calibration in airborne laser scanning. *ISPRS journal of photogrammetry and remote sensing,* 61(1), pp. 47-59.