Part scanning Report

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***Abstract*- Engineers in different areas of production increasingly using 3D scanning techniques, where speeding up the development process is one of the main factors for being competitive in today's market. Virtualizations of the physical objects, to recreate parts where drawings or CAD data are missing, or to make the change to the existing one is one of the main uses. From a wide range of commercial scanner used for digitalisation, 3D low-cost scanning system has gained a high interest. The aim of this paper is to show implementation of two low cost scanning systems for creating digital replicas of mechanical part. The process of the digital data acquisitions, processing and creating 3D virtual model will be presented. A good implementation of light condition, sensor size/type of digital camera in the photogrammetric system can achieve high LOD (Level of Detail) compared with structured light system. The displacement map generated from texture increase of the resolution geometry details as accurately as possible. Also for small parts the photogrammetry is more flexible or reliable.**

***Index terms*- 3D white lights scanning, photogrammetric, reverse engineering**

1. INTRODUCTION

3D scanning technique used for digital data acquisition of different the object are increasingly used by engineer in the different area of production where the speeding up the process of product development is one of the key factors for being competitive in today's market. Various applications can be found in different areas, as mechanical engineering, automotive industry, cultural heritage documentation, orthodontics, apparel industry, etc. Virtualization of the physical object, to recreate the parts where drawings or CAD data are missing, or making change to the existing one is one of the main use. Depending from interaction of sensor and the surface of objects, these systems can be divided as the contact or non-contact 3D scanner. Another classification of non-contact 3D scanner is active and passive scanning system. Selecting appropriate scanner based on the performance and cost for the digital data acquisition it's not an easy job. The first digital data are taken as point cloud information and then they are transformed into mesh. 3D model created after data processing can be used for the different applications, such as new product development, and simulation, performing data comparison, or reproducing the object by rapid prototyping technique.

Structured Light scanner projects pattern of light onto the object while digital cameras acquire image of the distorted pattern reflected by the object surface. These system are based on the triangulation principle for measuring object shapes. Low-cost system that developed by using off-the-shelf hardware as the webcam, projector, etc., give additional opportunities to gather the 3D information for further use in different application. They can be used in cultural heritage documentation, human body parts, or full body, creating CAD models of mechanical parts, industrial rubber parts.

Photogrammetry is another technique for object digitalization: it create 3D model form 2D images taken in 360 degree, with overlapping parts of images. Cultural heritage documentation is one of the main applications of the photogrammetric technique, for reproducing the artifacts without complex hardware or software.

Another applications of the photogrammetry is the creation of custom made garment by using 3D body models. Other authors have presented the development of the photogrammetric technique which is suitable for capture data even in sub millimeter-sized features. Different parameter effect on accuracy of the photogrammetric measures during the process of digital data acquisition. The focal length and the zoom of the lens, the resolution of the sensors are important factor that influence the reconstruction results of complex or simple shapes objects. Photogrammetric system is an accepted tool

in many areas of industrial manufacturing. Low cost scanning system are based on the close-range photogrammetry have many advantages respect to the laser and structured light scanners. Analysing the implementation of close range photogrammetry and laser scanning technique, they showed the similar results in point's clouds and 3D digital models.

2. METHODOLOGY

In this paper two low-cost 3D scanning system have been implemented for the mechanical parts digitalisation. The first is a 3D active lighting system, and is an upgrade of the existing setup done producing a new steel frame to incorporate two active camera. The second is a photogrammetric system done by using a DSLR camera and appropriate lighting condition. The 3D data created have been processed for the reverse engineering data manipulation.

1. Active scanning system

The active scanning system implemented consist on the same hardware and software as it was presented for footwear digitalization. In this new application setup gives us the possibility to add the another camera. For testing the performance of pattern quality, an upgraded projector with HD resolution (1920x1080) was used, as shown in Figure 1.

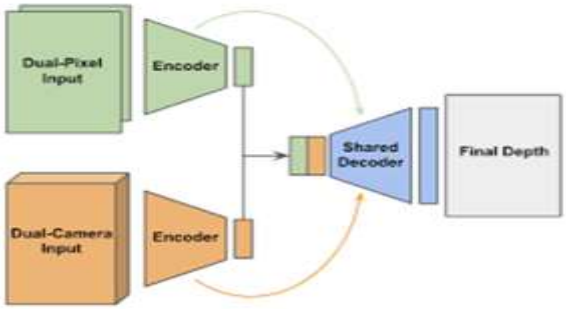


Figure 1. Dual camera Structured Light System design

Active scanning system result to be problematic with the reflective object surface. A thinner layer of white coating spray must be used to avoid the problem encountered during the scanning process of mechanical parts as depicted in Figure 2.

It's not the purpose of this work to test the accuracy of system setup but it can be considered in the range between 0.05 and 0.1mm. These result are very sensitive to board used for calibration, triangulation setup, lighting condition etc. A further work will show you in detail these influence on the 3Dscan.

(a) (b)

Figure 2. a) Non coated original parts (upper) and single scan; b) Spray coated parts (upper) and single scan.

The output could be elaborated with the different technique of the Reverse Engineering for creating precise models of original part. In Figure 3, the different steps of data manipulation are shown, from the point cloud to the solid model, with the optimised topology.

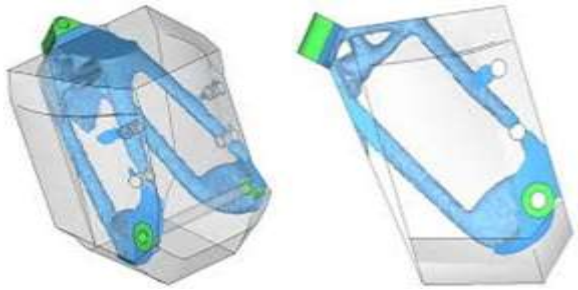


Figure 3. From point cloud to the optimised topology

2. Passive photogrammetric scanning system

The proposed methodology is based on following step:

1 work piece positioning, lighting and the camera setup;
2 RAW data capturing;
3 photogrammetric elaboration.

A DSLR camera NIKON D5300 equipped with NIKKOR AF-S 50 mm 1:1.4 G lens type are used with the remote camera control. All the setup is enclosed in white box 1x1x1m with halogen lighting lamps inside a platform and with adjustable distance for cutting off reflection as much as possible. As

shown in a Figure 4, the total number of 113 single images were elaborated on the Agisoft Photoscan to create a 3D model of differential car block. In the Figure 5 are presented close-up view of level of details LOD(level of details) to show mesh quality from the data manipulations. As can be seen texture quality generated with this system is better as compared with the Structured Light system. Agisoft Photoscan is based on SFM (structure-from-motion) and dense multi-view 3D reconstruction (DMVR) algorithm.

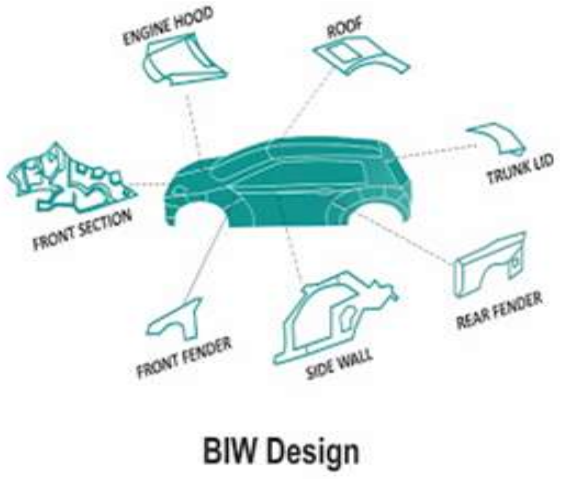


Fig. 4. 3D reconstruction of the differential car block

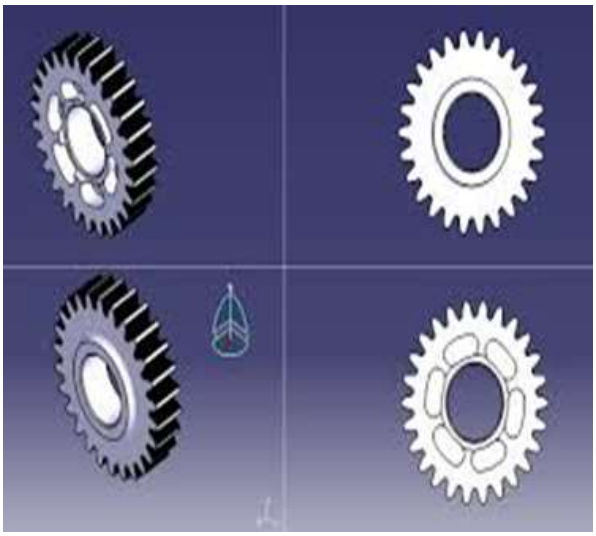


Fig. 5. LOD of the photogrammetric system.

Another 3D photogrammetry solution which can elaborate a big amount of single imagewithout necessity to have high cost PC is Context Capture. This is done by tiling the option which does not require the higher hardware capabilities. As shown in the Figure 6 and Figure 7 a 3D object of the diesel engine with real dimension of 1050x1295x760mm, is created by 487 single images and 158 volumetric tiling blocks.

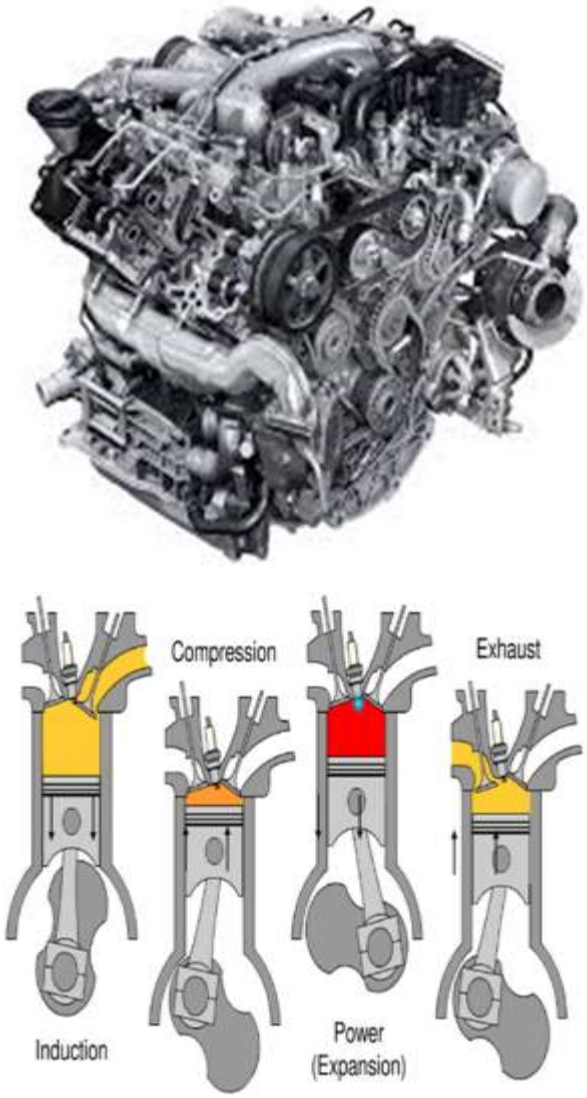
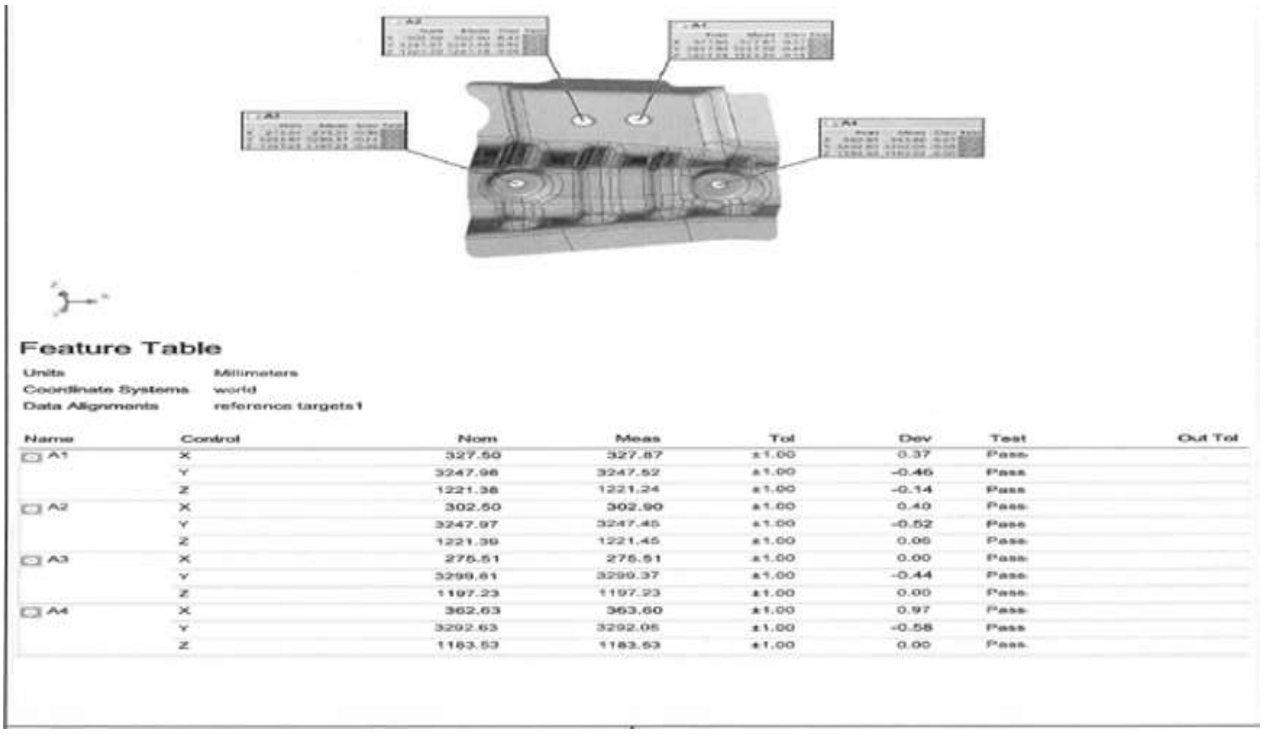


Fig. 6.3D model of the diesel engine by Context Capture. Fig. 7. Close-up LOD generated with the Context Capture.

3. PROCESS

Stages:- Part Scanning Report system generated > Part accuracy data> Part accuracy Graph

Step 1 – First of all scanning of part will be done by the system and then combine pdf of all the part is generated by the system. One of the page in image form we get from the part scanning report system generated. Shown below in figure 8.

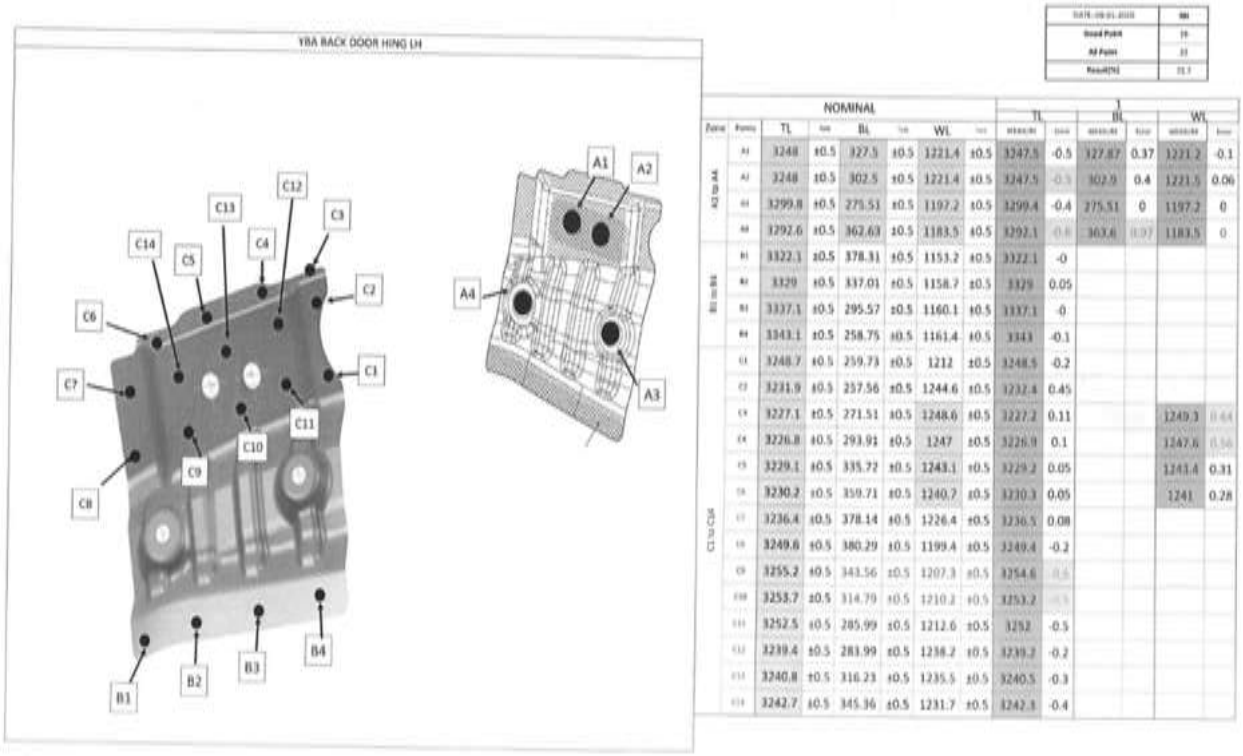


Feature Table

Units		Millimeters					
Coordinate Systems		world					
Data Alignments		reference targets1					
Name	**Control**	**Nom**	**Meas**	**Tol**	**Dev**	**Test**	**Out Tol**
A1	X	327.50	327.87	±1.00	0.37	Pass	
	Y	3247.98	3247.52	±1.00	-0.46	Pass	
	Z	1221.38	1221.24	±1.00	-0.14	Pass	
A2	X	302.50	302.90	±1.00	0.40	Pass	
	Y	3247.97	3247.45	±1.00	-0.52	Pass	
	Z	1221.39	1221.45	±1.00	0.06	Pass	
A3	X	276.51	276.51	±1.00	0.00	Pass	
	Y	3299.81	3299.37	±1.00	-0.44	Pass	
	Z	1197.23	1197.23	±1.00	0.00	Pass	
A4	X	362.63	363.60	±1.00	0.97	Pass	
	Y	3292.63	3292.05	±1.00	-0.58	Pass	
	Z	1183.53	1183.53	±1.00	0.00	Pass	

Fig. 8. Part Scanning report system generated

Step 2 – After generating the pdf, accuracy data of the part is made by one of the employee in a excel sheet. As you can see in the figure 9 left side image isthe part that is scanned and in the right side the values are entered that get from "Part Scanning Report System Generated", also that we get are from x, y and z axis.



		NOMINAL															
		TL		BL		WL		TL		BL		WL					
	A1	3248	±0.5	327.5	±0.5	1221.4	±0.5	3247.5	-0.5	327.87	0.37	1221.2	-0.1				
A2 to A4	A2	3248	±0.5	302.5	±0.5	1221.4	±0.5	3247.5	-0.5	302.9	0.4	1221.5	0.06				
	A3	3299.8	±0.5	275.51	±0.5	1197.2	±0.5	3299.4	-0.4	275.51	0	1197.2	0				
	A4	3292.6	±0.5	362.63	±0.5	1183.5	±0.5	3292.1	-0.5	363.6	0.97	1183.5	0				
	B1	3322.1	±0.5	378.31	±0.5	1153.2	±0.5	3322.1	-0								
B1 to B4	B2	3329	±0.5	337.01	±0.5	1158.7	±0.5	3329	0.05								
	B3	3337.1	±0.5	295.57	±0.5	1160.1	±0.5	3337.1	-0								
	B4	3343.1	±0.5	258.75	±0.5	1161.4	±0.5	3343	-0.1								
	C1	3248.7	±0.5	259.73	±0.5	1212	±0.5	3248.5	-0.2								
	C2	3231.9	±0.5	257.56	±0.5	1244.6	±0.5	3232.4	0.45								
	C3	3227.1	±0.5	271.51	±0.5	1248.6	±0.5	3227.2	0.11			1249.3	0.44				
	C4	3226.8	±0.5	293.91	±0.5	1247	±0.5	3226.9	0.1			1247.6	0.56				
	C5	3229.1	±0.5	335.72	±0.5	1243.1	±0.5	3229.2	0.05			1243.4	0.31				
	C6	3230.2	±0.5	359.71	±0.5	1240.7	±0.5	3230.3	0.05			1241	0.28				
C1 to C14	C7	3236.4	±0.5	378.14	±0.5	1226.4	±0.5	3236.5	0.08								
	C8	3249.6	±0.5	380.29	±0.5	1199.4	±0.5	3249.4	-0.2								
	C9	3255.2	±0.5	343.56	±0.5	1207.3	±0.5	3254.6	-0.6								
	C10	3253.7	±0.5	314.79	±0.5	1210.2	±0.5	3253.2	-0.5								
	C11	3252.5	±0.5	285.99	±0.5	1212.6	±0.5	3252	-0.5								
	C12	3239.4	±0.5	283.99	±0.5	1238.2	±0.5	3239.2	-0.2								
	C13	3240.8	±0.5	316.23	±0.5	1235.5	±0.5	3240.5	-0.3								
	C14	3242.7	±0.5	345.36	±0.5	1231.7	±0.5	3242.3	-0.4								

Fig. 9. Part accuracy data

Step 3 – After completing the excel sheet, graph of the part is generated linking to the part accuracy data excel sheet as shown in fig. 10.

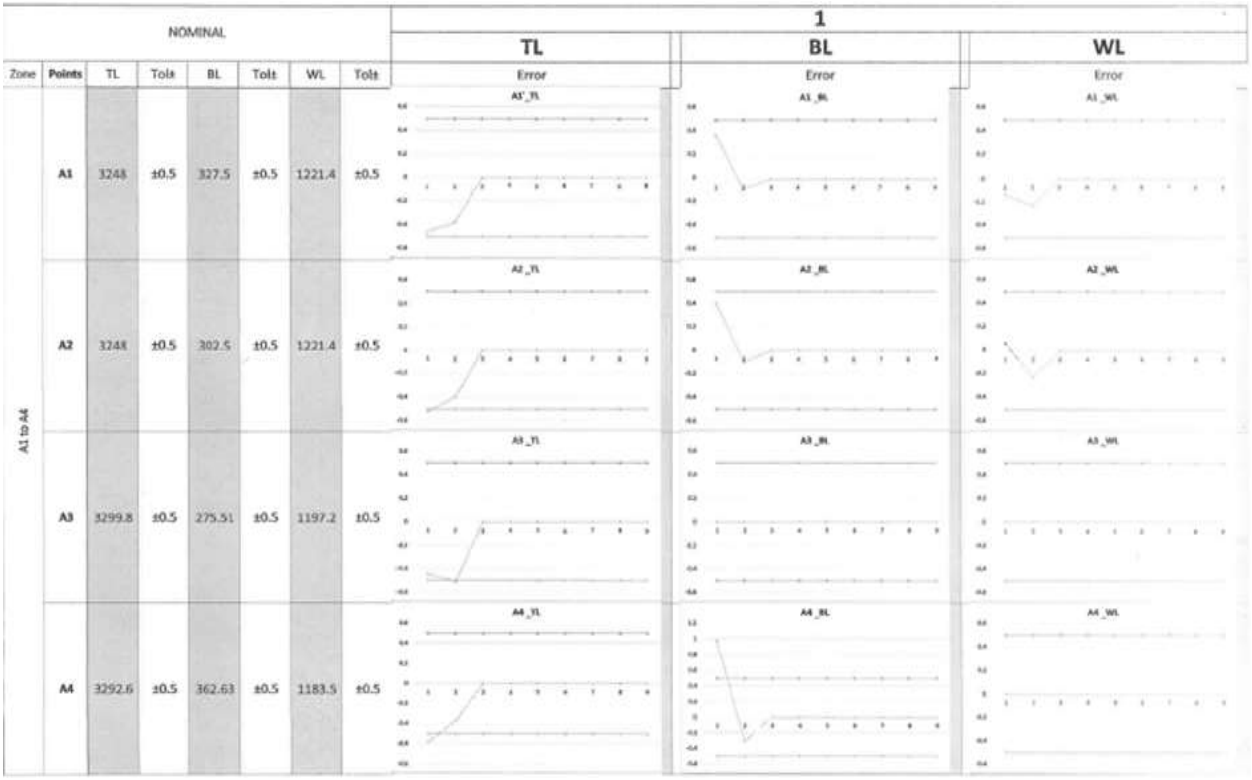


Fig. 10. Part accuracy Graph

4. CONCLUSIONS

The aim of this paper was to show implementation of the two low cost scanning systems for creating digital replica of mechanical part. The good implementation of light condition, sensor size/type of digital camera in the photogrammetric system can achieve the higher LOD compared with structured light systems. The displacement map generated from texture increase resolution geometry details as accurately as possible. Photogrammetry is much simple and flexible, also for small part. It was noticed that using HD projector in active scanning system does not increase 3D data resolutions. The most sensitive was resolution of active sensor. By using two active sensor, alignment process was more accurate. Results about the data comparison in terms of accuracy, resolution and other feature will show the advantage and disadvantage of the scanning systems, which are part of another project.

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