Re-Designing a Gear Using Reverse Engineering

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Abstract

This paper describe our approach in reverse engineering (RE) using "Artec space spider " scanner then design using " Geomagic Design X " software , to extract the CAD model firstly by scanning & getting the mesh then model it in the Geomagic , This report describe the technique and method we used to come up with the CAD model using an existing physical model. A case study of reverse engineering using Artec space spider & Geomagic Design X for a Gear that was requested in our Machine Design II course .

Keywords
Reverse Engineering, Gear, 3D scanner , Geomagic Design X

1. INTRODUCTION

Reverse engineering also well-known as back engineering. Is the process of reproducing of a certain part with unknown measurements, sketch model or any information related to that part. The goal of reverse engineering is to collect the whole engineering design data about the physical existing part, which allow the opportunity for recreation. The mechanism of reverse engineering should include 3D scanner and a software that match 3D scanner machine, with the help of Geomagic Design X to extracts the CAD model.
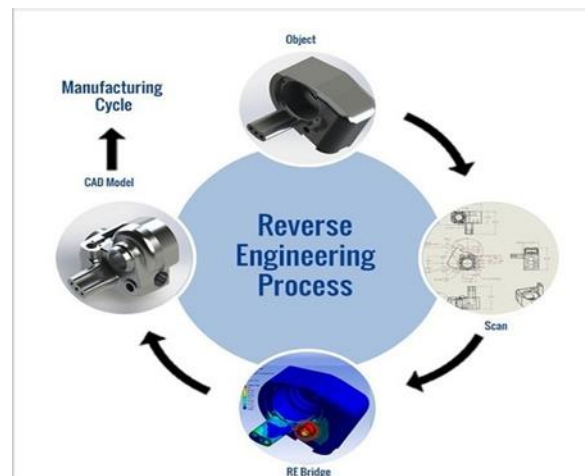

Figure 1: Reverse Engineering Process

Need for Reverse Engineering:

- Recovery of a broken or damaged existing part.

- Improving quality and efficiency of existing parts.
- To assess and analyze the competitors 'product.
- To identify the bad and good characters of working part.
- The design or implementation information has been vanished or lost.
- Performance of rapid prototype and reliability testing and evolution.
- Accomplish of CAD model for the existing part.
- To uncover the undocumented features of a product.
- Assisting with maintenance
  identification of side effects and anomalies.
- Fix problems with the product that specially not supported by their original creators.
- Products that are no longer useful get reverse engineered they will be improved upon and made useful once again.
- Helping Innovative Product Development.
- Figuring Out the Reasons of Product Failure.

Furthermore, techniques like 3D scanning and rapid prototyping are widely recommend in the manufacturing world. The technique will be operating in this project is 3D scanning. Which to abduct an accurate drawing of a part and be able to be manufactured once again.

1.1 OBJECTIVES

- To study and get an overview of reverse engineering.
- To produce a representation of the existing part in another model or at a higher level of precision.
- To identify the part's components and their interrelationships.
- To abstract and analyze the dimensions of a part.
- To detect side effect of a physical part.
- To use 3D scanning accurately to obtain accurate dimensions.
- To study a scanning software called Artec Studio 12 Professional that can be used in STL data to create a CAD model.

1.2 PROBLEM STATEMENT

In this project, the gear from mechanical workshop in UAEU which needed in our machine design II project. Which is one of the important components in a gear box. The precise dimensions or the CAD model is not assessable any more, but the finish part is available to apply the reverse engineering. Mention the fact that inaccuracy in geometrical features which create failure in assembly process. In result, some improvement will acquire in this part by Reverse Engineering using Artec Space Spider.

1.3 ATREC SPACE SPIDER

Space Spider offers almost unlimited possibilities in areas such as reverse engineering, quality control, product design and manufacturing. Also, it's a high-resolution 3D scanner based on blue light technology. It is perfect for capturing small objects or intricate details of large industrial objects in high resolution, with steadfast accuracy and brilliant color. It is an ideal industrial 3D scanner for high resolution capturing of objects such as molding parts, PCBs, keys, coins or even a human ear, followed by the export of the final 3D model to CAD software. (Artec Space Spider.com, 2018).

Figure 2:Artec space spider

2. LITERATURE REVIEW

The dramatic advancement is increasing gradually nowadays , which affect most technologies in our life, The starting point was in digitizing sound using signal processing which was in 1970s , that allowed us to convert from analog to digital and that's viewed to be (1D) . The 1980s opened the door for digitized font and pictures (2D) . finally in 1990s people focused on digitizing the physical world using geometry processing (3D), which is considered as the starting stone for reverse engineering .

Reverse engineering is a quite useful tool which allowed us to manufacture things easily, one of the popular examples of using it was in second world war & cold war , where they tried to obtain military technology , devices & information from other nation and countries . In addition it played a big role in aviation industry due to advancement of modern technologies and market demand (Kumar et al., 2013).

However there are many studies in the field of reverse engineering, Z.Q. Cheng et. al. (2001) presented reverse engineering for '' four door 1997 Honda Accord DX Sedan ''which was used to create finite element model, The model had significant impact in simulation full frontal, offset frontal, side, and oblique car-to-car impacts. The simulation results were validated with test data of actual vehicles

A.R. Ismail et. al. (2009) used reverse engineering in producing four stroke piston engine by explaining the modeling and machining ,Their first step was layout machine to capture the point clouds and following by the Computer Aided Design (CAD) stage and Computer Aided Manufacturing (CAM) stage using Unigraphics NX2 software , which allowed them to reconstruct the piston engine surface.

3. CONCEPT

Creating geometric models of existing objects for which no such model is available, is quite needed in many areas of most industries . This process is known as Reverse engineering . The basic concept of producing a part based on an original or physical model without the use of an engineering drawing , this is how Abella et al. (1994) described Reverse Engineering (RE).

4. Material and method

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source.

Figure 3: A Gear

4.1 Machine used

The Artec Space Spider machine is used in this study which is shown in figure 2 the technical details of this machine are:

4.2 Specifications

Fast scanning speed: 7.5 fps
High 3D point accuracy: 0.05 mm
Texture Resolution: 1.3 Mpx
Impressive 3D Resolution: 0.1 mm

4.3 Performance data

The scanner is able to render complex geometry, sharp edges and thin ribs sets our technology apart. It is an ideal industrial 3D scanner for high resolution capturing of objects such as molding parts, PCBs, keys,
coins or even a human ear, followed by the export of the final 3D model to CAD software.
Space Spider offers almost unlimited possibilities in areas such as reverse engineering, quality control, product design and manufacturing.
Originally developed to spec for the International Space Station, this next generation industrial 3D scanner features powerful temperature stabilization and high grade electronics, which not only allow the scanner to reach maximum accuracy in three minutes but also ensures long-term repeatability in data capture, since the accuracy rate of the device is not affected by fluctuations in environmental conditions (Artec Space Spider.com, 2018).

4.4 The detailed procedure for Artec Space Spider scanning

- Step 1: Starting the program
Open the Artec Space Spider Program by double clicking on the Artec Space Spider icon.
- Step 2: Scanning the part

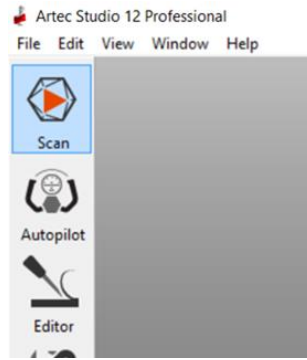   1- Press scan to start scanning

Figure 4: Press scan to start scanning

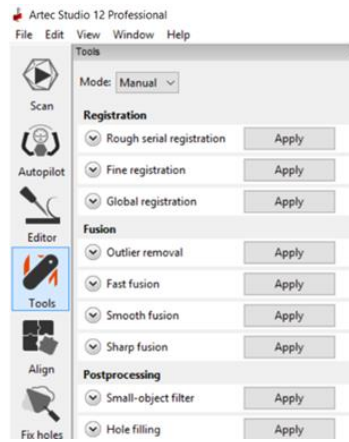2- Press tools and apply the following: global registration, outlier removal, and sharp fusion.

Figure 5: Tool dialog box

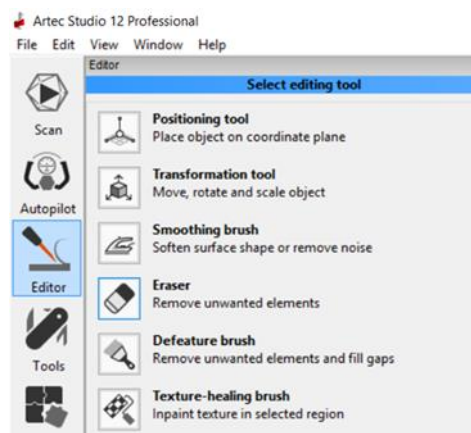3- Press editor to select the editing tool which is the Eraser

Figure 6: Eraser dialog box

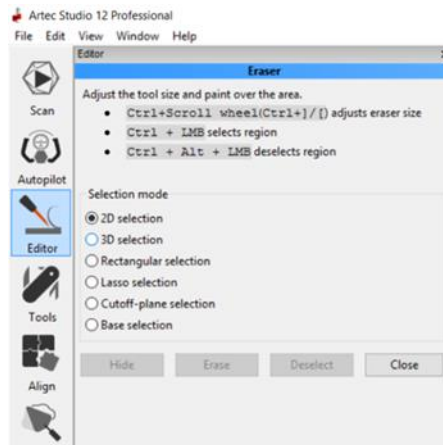4- In the Eraser follow the instruction and choose 2D selection

Figure 7: 2D selection from Eraser dialog box

- Step 3: Save the part

Save the scanned part as STL file.

5. Methodology Adopted

On the basis of mentioned objectives the following steps are taken:
• Selection of component
• To scan the component with Artec Space Spider and export it to the modeling software.
• To prepare a CAD model
• To inspect the part

5.1 Selection of component

The first step is to find the suitable part for the study to perform the reverse engineering method for it, taking on consideration the resources available, time period, complexity, and functions provided. Based on that it was feasible to take the gear part as a study component. It is found that the technicians in UAEU labs doesn't have a CAD model of this part. So the main problem of this paper work is concentrated on studying the part and choosing the best method for developing the CAD model to generate a new gear part without the available defects in the previous one.

5.2 To prepare a CAD Model

Once the part is scanned and saved it will be imported to the Geomagic Design software to start developing the CAD model.
CAD modeling with the help of Artec Space Spider scanning is done by the following steps:
1- Scanning with the help of Artec Space Spider and saving the part as STL file.
2- Import and open the STL file in Geomagic design software.
3- Start making the CAD model in the software.

5.3 Scanning with the help of Artec Space Spider

The detailed scanning procedure is already explained

5.4 To inspect the part

Once the scanning process is completed the gear can be tested using gear measuring machine, to measure the accuracy of tooth profile, tooth trace (flank line), pitch and runout.

5.5 Exporting the mesh to Geomagic

Once the mesh was created from the 3D Scanner , the file will be saved as Stl. file and export to the geomagic software .

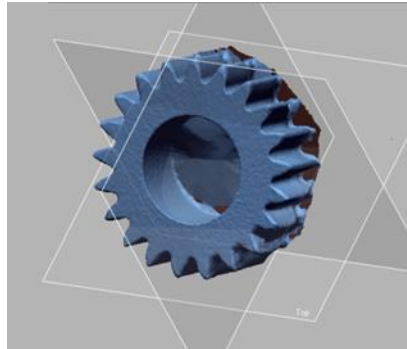When the mesh is generated and exported to Geomagic it will show

Figure 8: Mesh in Geomagic

After importing the Stl. File we need to do auto segmentation which will classify the mesh into different color geometric regions based on the curvature and features of the scan data.
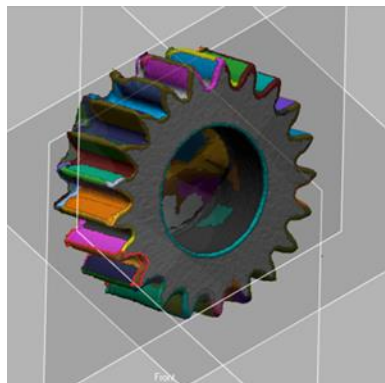

Figure 9:Auto Segement Applied

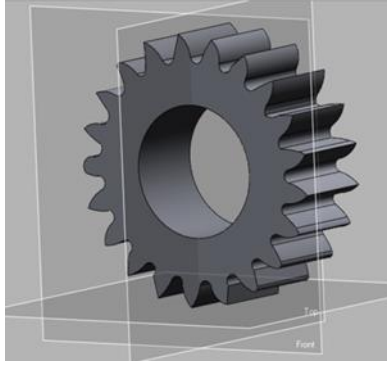After the auto segment phase the design stage will begin

Figure 10: The Model

Design procedure is adding solid to the mesh & extract features to complete the CAD file .
However , after modeling we need a tool which indicate to us whether we are on the right track or not so we use the
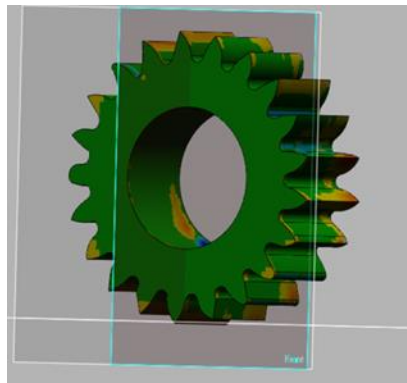" Accuracy Analyzer " to if our model matches the mesh .

Figure 11: Applied Accuracy Analyzer

After applying the Accuracy Analyzer it showed us mostly green regions which indicate that our model coincide
with the mesh.

6. Results and discussion

Table : Comparison between scanned part measurements and the modeled part

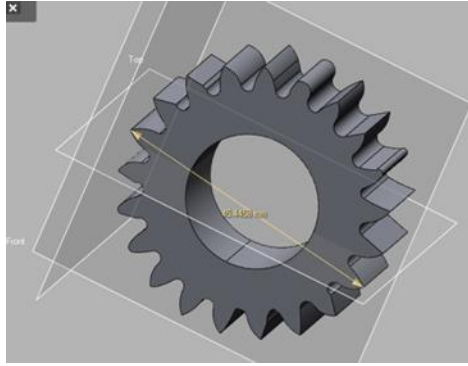| Sr. No	Part	Scanned part measurements (mm)	Modeled part measurements (mm)
1.	Outside Diameter	45.4	45.44
2.	Inside Diameter	21.43	22.2
3.	thickness	14.89	14.9

Figure 12: Sample measurement in Geomagic

As shown in the table the modeled part has measurement which matches the original part which tell us that our scan was successful and it captured most of the features , In addition now it's ready to be 3D printed or manufactured because we obtained the CAD file.In the second model we tried to repair the defect areas of the gear so it will be brand new .

7. Conclusion

In conclusion a gear part have been selected to be modeled due to the defects appeared in the original part, and the need for new part in a very limited time.

In this paper work the scanning of the gear is done with the help of Artec Space Spider machine, then the part has been imported in a CAD software which is Geomagic Design for developing a model for it.

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Kumar A.; Jain, P. K. & Pathak, P. M,(2013)," *Reverse Engineering In Product Manufacturing: An Overview* ",DAAAM international scientific book. Chapter 39, pp. 665-678

Biographies

Hoor Alhafeiti is an undergraduate bachelor student in mechanical engineering department in the United Arab Emirates University , a certified CATIA designer ; has accomplished industrial training in TAWAM Hospital under UAEU required course which included training in the maintenance , projects & the biomedical department , Ms.Hoor is in the final year working on her graduation project with the title " Heat Recovery System " .

Ms.Hoor is currently working on (UGRU) undergraduate research opportunities in Aerospace engineering and related technologies under project title " Designing, developing and implementing of a portable and stationary wind tunnel smoke visualization systems " which is funded by Mubadala Company. In addition to (SURE) Summer undergraduate research opportunities in a research involve working with material technologies . Ms.Hoor is currently participating in a project of Portable cleaning device for solar panels in I2P (Idea to prototype) program .

Aiman Ziout is assistant professor at mechanical engineering department at UAEU. He obtained his Bachelor and master degree from University of Jordan in Industrial Engineering. He accumulated professional experience in production management, mainly in steel industry. He obtained his PhD from University of Windsor-Canada. His main focus is sustainable production and sustainable product design. Currently he searches application of SMA in sustainable product design

Athari Alsaadiya is a bachelor student in mechanical engineering department in United Arab Emirates University, Athari accomplish a training course in SEWA under UAEU required course which includes field trips, research and implantation the knowledge in real life. Athari is in her final year working on her graduation project of Development of an Educational Energy Harvester from Mechanical Vibration due to Rotating unbalance to successfully accomplish her bachelor's degree in mechanical engineering.

Athari is currently participating undergraduate research opportunities in Aerospace engineering and related technologies under project of Designing, developing and implementing of a portable and stationary wind tunnel smoke visualization systems. Athari accomplish a project under the name Technology Whisper In Corrosion in Think Science Connect-Platform in 2017 with live experiment to show the effect of corrosion in our life. Athari is currently participating in a project of Portable cleaning device for solar panels in I2P program.

Asma Alhebsi is a bachelor student in mechanical engineering department in United Arab Emirates University. The student is currently working on her graduation project of development a mobile robot with inverted pendulum to fulfill her bachelor degree in mechanical engineering. In addition the student is working in undergraduate research opportunities in Aerospace engineering and related technologies which is, quadrotor controller and autopilot mechatronics system development using an In-house developed quadcopter testbed. The student fulfills her internship in one of Mubadal's company in UAE which is Turbine Services And Solutions.