

A REVERSE ENGINEERING APPROACH TO OBTAIN THE 3D MODEL OF A SPARE PART

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ABSTRACT: The current stage is characterized by the steady growth of competition between manufacturing companies, which causes diversifying the range of products and find new methods to shorten the time for the development of a new product. There are several concerns in this respect, one of them being the reverse engineering, which uses information from an existing product that can be processed, analysed and used for the design of a new product or for achieving a copy of the current product in a situation in which the spare parts are required. The current manufacturing is based on the use of the digital data of the virtual model of the workpiece which must be achieved. This paper presents the use of reverse engineering in order to obtain the 3D model of a complex piece, the purpose being to manufacture spare parts.

KEYWORDS: reverse engineering, complex surfaces, spare part

1. INTRODUCTION

In the market economy companies are confronted with strong competition, which, by technological development is becoming more and more dynamic. The success on the market is influenced by diversifying the range of products and the use of high-performance technologies to ensure the development of products in a short time as possible and also to have better characteristics than of the products from the competing companies [2].

The economic growth of the company is not always to manufacture a product for a long time and in large quantities, but in many situations, the success is ensured by the production of low amount of products, but tailored to meet the needs of a specific category of customers. In many situations, the traditional design process becomes cumbersome as it involves moving away from the abstraction level to the logical drawings and then to the physical implement model. In this case, one of the best performing solutions that ensures the development of products for a short time is reverse engineering technology [3] [5].

Reverse engineering is a process by which is obtained the 3D virtual model of an existing physical object. As it is mentioned in the paper [1] reverse engineering represents the process by which an existing product for which there is no documentation or drawings, can be reproduced.

The reproduction of an object begins with its measurements. The measurement can be performed with traditional instruments, coordinate measurement machines (CMM), or 3D scanning [6].

In the current stage of development, by reverse engineering you mean to obtain a virtual CAD model of a real object by using digital data resulted by measuring on coordinate measuring machine or by using 3D scanners. The use of coordinate measuring machines has the advantage that it ensures precise data from the object to be measured, but the effective measurement takes a longer time. By comparison with this method, 3D scanning provides the acquisition of vast quantity of data for a very short time [4], [7].

Reverse engineering is based on a theory of design and measurement technology which enable the transformation of physical product for a virtual model to reproduce it, or for the redesign, and which has applicability in many situations such as [5]:

- Production of spare parts when:
 - The manufacturer no longer exists or it is not known;
 - The manufacturer exists, but no longer is manufacturing the product;
 - There are no documents for the manufacturing of the workpiece;
 - The achievement of the required documentation for digital manufacturing of parts with complex shape;
 - For reproduction of a product in order to analyse its characteristics;
 - In a situation in which an existing object must be reproduced to a specific scale;
- In the medical field to generate data needed to achieve prostheses

- In archaeology for the reconstruction of objects based on their existing pieces;

2. THE REVERSE ENGINEERING PROCESS

The process of obtaining the virtual model of an object through reverse engineering involves performing the following steps (Figure 1):

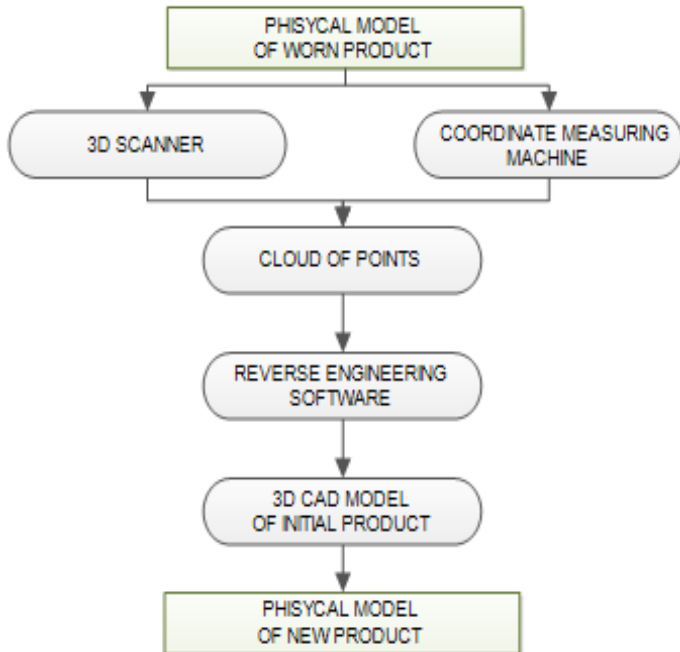


Figure 1. Schematic diagram of the reverse engineering process.

Scanning the existing physical object. This can be done by coordinate measuring machines or by 3D scanners. In this step, we obtain a set of digital data (cloud of points) that contains the coordinates of the points on the surfaces of the scanned object.

The next step in the process of reverse engineering is the processing of digital data in such a way as to be reproduced the scanned object faithfully.

This operation implies the use of dedicated software for reverse engineering.

The next step uses the previously processed digital data to create the 3D virtual model of the scanned object, which then can be used for digital manufacturing.

In Figure 2 is shown the object which should be scanned in order to obtain the 3D model with the aim of producing spare parts.

The part to be reproduced is made of aluminium and is delimited by the curved surfaces which make difficulty its measurement by traditional methods.

In this paper are presented the steps to obtain CAD model through reverse engineering using 3D scanning.

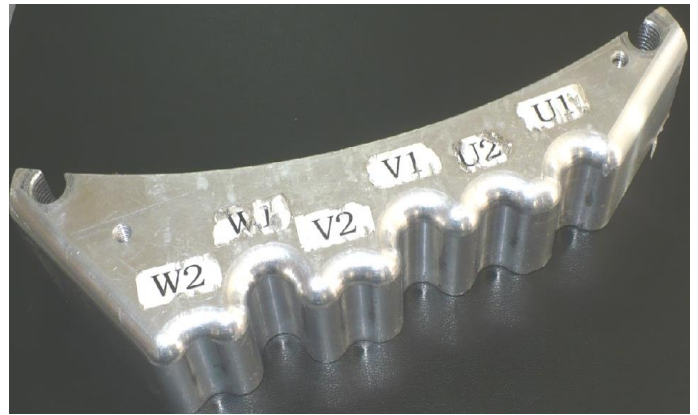


Figure 2. The part which is reproduced.

The used equipment consists of 3D Optim II scanner and software application for reverse engineering. The scanner (Figure 3) is equipped with two 3-megapixel cameras and with blue light [8].



Figure 3. The 3D scanner.

The scanner is equipped with dedicated software which allows data acquisition and processing the cloud of points.

They are allowed scans in manual or automatic mode, and you can acquire data from objects which do not contain markers, in this case, the alignment of the scanned data is performed manually.

The scanning software allows scanned data to be saved in various formats recognized by the reverse engineering application.

Figure 4 shows an aspect during a scan, and Figure 5 presents the data obtained after ten successive scans.

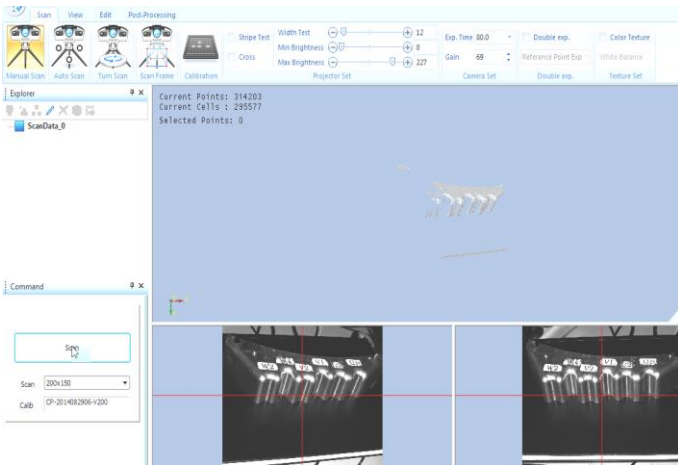


Figure 4. An aspect during a scan.

At the beginning are removed the parasite points related to each scan. The parasite points come from elements which are in the field of view of the two cameras of the scanner. These points should be identified and eliminated so that in the end there will be only the points belonging to the surfaces of the scanned object.

The next step consists in pre-alignment of data relating to each of the scans.

For this, it shall set a primary scan data, and the others will be aligned with this. This operation can be done automatically, and in a situation in which errors may occur, the orientation of the scanned data may be corrected manually. Figure 7 shows the pre-alignment of scanned data.

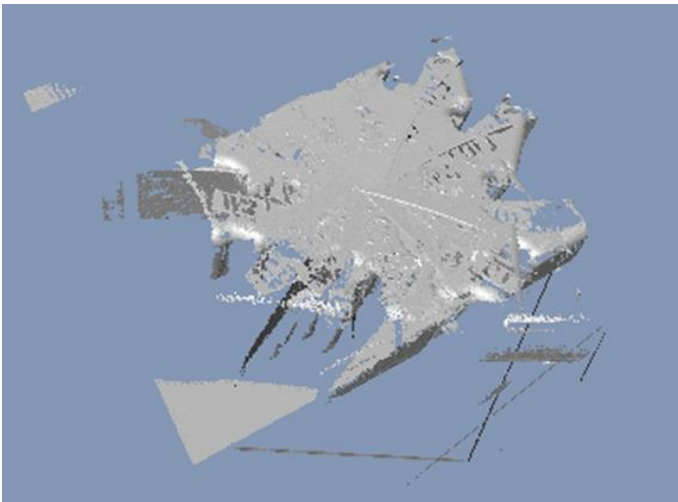


Figure 5. The scanned data of the object.

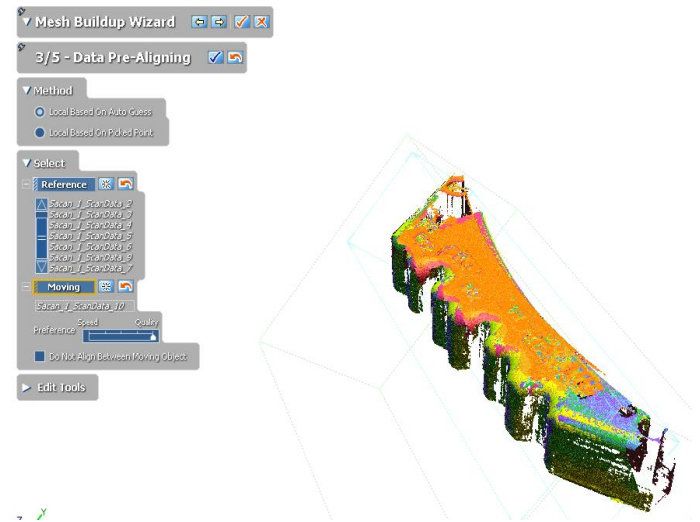


Figure 7. Pre-alignment of scanned data.

The next step is the best alignment of the scanned data; the reverse engineering application having a high performing feature for this purpose. The data resulting from such accurate alignment are shown in Figure 8.

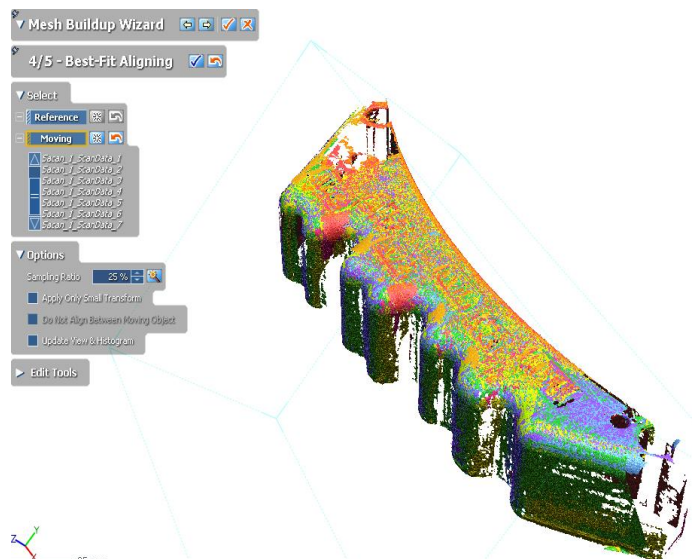


Figure 8. Result after best fit alignment.

For processing the scanned data and obtaining the cloud point of the original product was used Shiningform XOR application.

In order to obtain the cloud of points of the product being scanned there are required several steps.

The alignment of the scanned data has been achieved in this application which has additional facilities and allows a much more comfortable work.

The data previously scanned are imported into the application of reverse engineering (Figure 6).

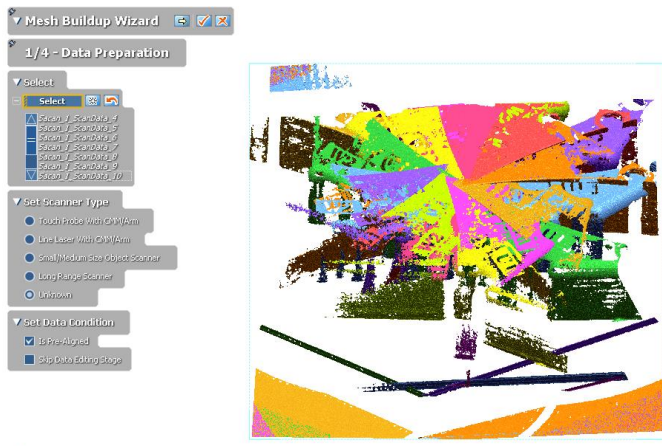


Figure 6. The imported scanned data in reverse engineering application.

The reverse engineering application allows determining the accuracy of the mesh. (Figure 9).

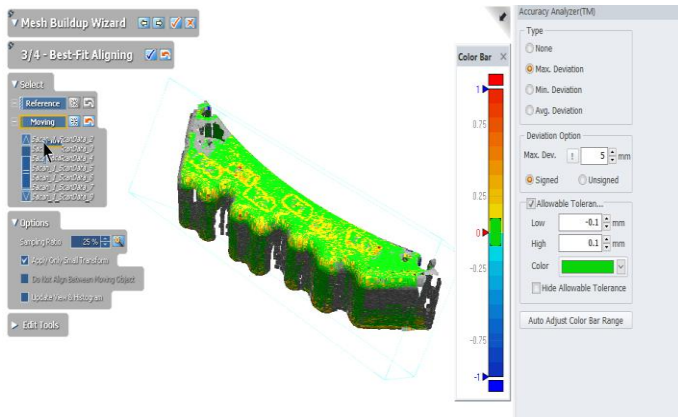


Figure 9. The accuracy of the mesh.

The right side shows a map concerning the significance of colors, from which it can be seen that the cloud of points approximates by an accuracy of ± 0.1 mm the dimensions of the original object. The tolerance field was imposed by the beneficiary of spare parts.

The mesh is shown in Figure 10.

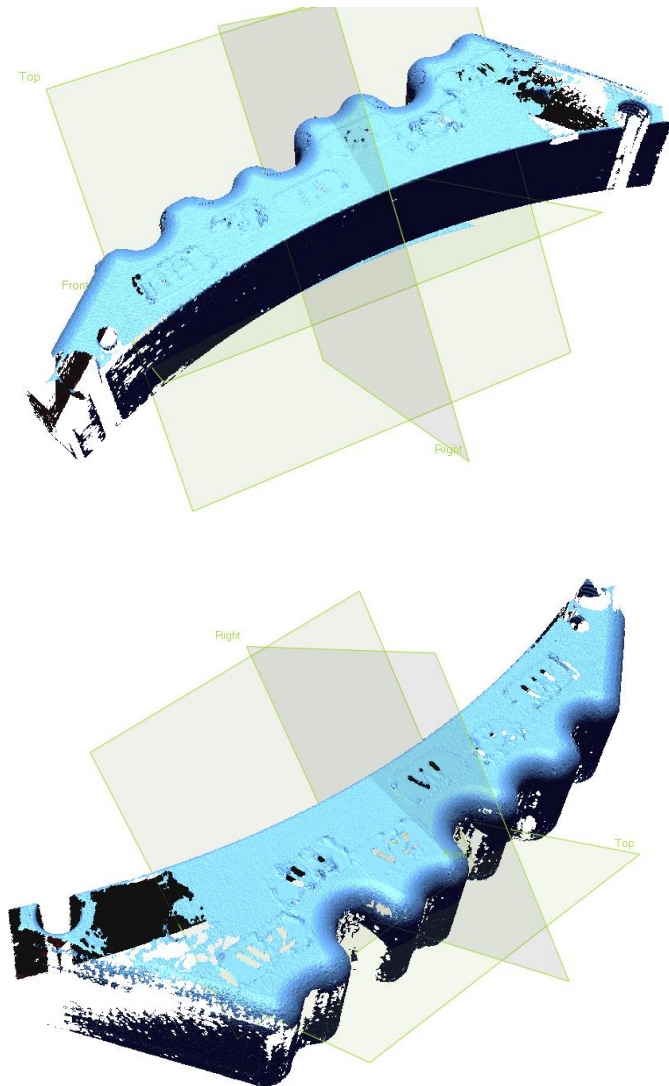


Figure 10. The mesh of the original object.

3. 3D MODELLING OF SPARE PART

The 3D model was achieved by importing the mesh in Siemens NX application, which contains a well-developed module for reverse engineering and has the advantage that it allows a more convenient 3D modeling.

In order to achieve a 3D model as faithfully as possible there are needed as many points as possible to the outline of the part-piece.

As you can see from figure 10, the mesh has some faults regarding the continuity. This is due to metallic luster of the object surface, whereas was not allowed applying a matte coat on the surfaces subjected to scanning. In order to obtain points from the contour of the part mesh, this is intersected with a parallel plane. Taking into account the quality of the mesh, were used for intersection three parallel planes situated at 10 mm from each other, to obtain as many points as possible to construct an accurate outline. (Figure 11).

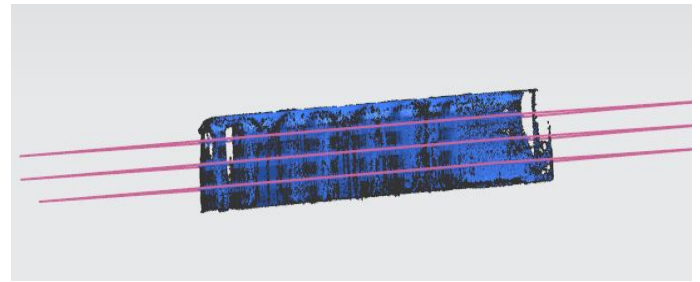


Figure 11. The mesh intersection with the three planes.

The result of the intersection of the mesh with the three planes is shown in Figure 12.

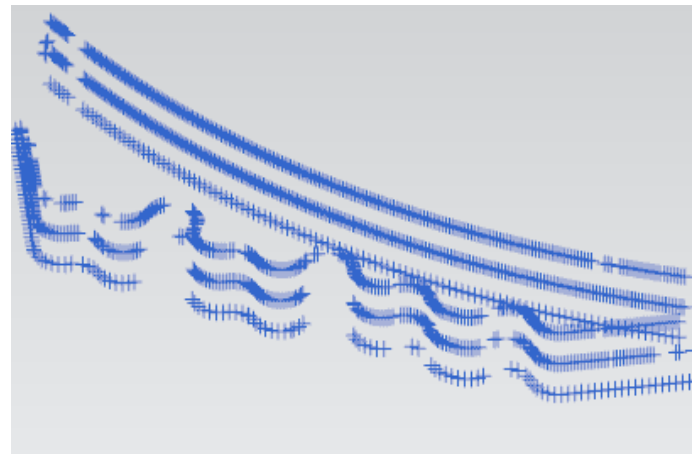


Figure 12. 3D view of intersection points

Obtaining the 3D model requires a sketch of the contour of the scanned object. To do this, all the points resulted from the intersection of the mesh with the three planes are projected to the plane in which the sketch is being constructed. The outline sketch is obtaining by joining all the points projected on the sketch plane by using linear, circular or spline segments (Figure 13).

