Application of reverse engineering techniques in automotive component design

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Abstract: *The aim of the work was to digitize an automotive component using reverse engineering. To apply the procedures by which an automotive component can be designed. Reverse engineering belongs in the field of innovation among the first established knowledge-intensive services. Together with the advancing development of technology and utilizing of 3D scanning, the reverse engineering is becoming an important tool for accelerating the product innovation cycles and increasing the potential of lean approach and agility of development processes in Product Design. The paper illustrates the possibilities of using and experience with these tools on examples of the scanning of the geometry of the selected automotive components.*
Keywords*: REVERSE ENGINEERING, 3D SCANNMG, AUTOMOTIVE DESIGN, RAPID PROTOTYPING*

1. Introduction

At the Technical University of Kosice, there was established the Product Design laboratory, where are used 3D scanners MicroScribe G2 and FARO Laser Scanner PlatinumArm in combination with software Rhinoceros, PolyWorks and Autodesk Maya 2012. The possibilities of using and experience with these tools on examples of the scanning of the geometry of the selected automotive components are the main works in this lab.

Digitizing of automotive components is a part of reverse engineering. This process includes transformation of real component shapes to digital form. Result of those actions is mostly a cloud of points, which can be in the future used for e.g. rapid prototyping or product design etc. [1, 2, 3]

Digitizing includes some problematic actions. One of the most problematic are:

- 3D scanning of large-size components and connected operations
- 3D scanning of components with improper surface colour

2. 3d Scanning of large-size components

One of the problematic operations by 3D scanning is large-size components scanning. Large- size components need to be scanned in more steps. Through this kind of scanning partial scans are made. Final points cloud is made by connecting of these partial scans. These operations are demanding for hardware equipment.

Example of this kind of 3D scanning can be e.g. 3D scanning of car petrol tank (Fig.1).

Fig. 1 *Petrol tank prepared for 3D scanning.*

Dimensions of such a petrol tank are bigger than 3D scanner arm possibilities used in our lab (1,8m). This kind of scanning arm allows us to scan component only through partial scans, which are to be connected.

Before 3D scanning process it's necessary to choose a group of planes, which will be scanned in all partial scans. With the help of these planes, the partial scans will be connected. In submitted example of 3D scanning were as an initial group of planes a clip surfaces chosen (Fig.2).

Fig. 2 *Petrol tank prepared for 3D scanning.*

During the scanning process is though choosing an initial group of planes further necessary to made some help planes, which will be useful for better best-fit operations. These planes are chosen by consider (Fig.3).

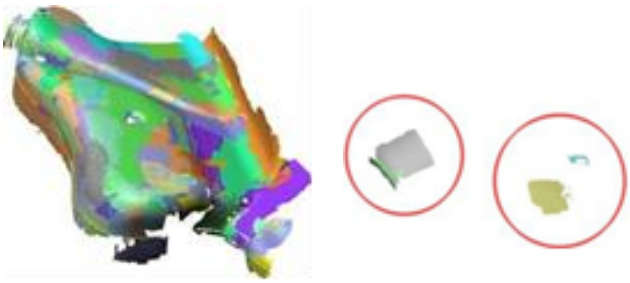

Fig. 3 *Sample of help planes scanned for best-fit operations.*

Another step before 3D scanning is to divide component to several parts which overlay each other. For demonstrative example we 'll show you best-fit of first two partial scans. The I st scan is bigger and creates the base for entire 3D scan (Fig.4).

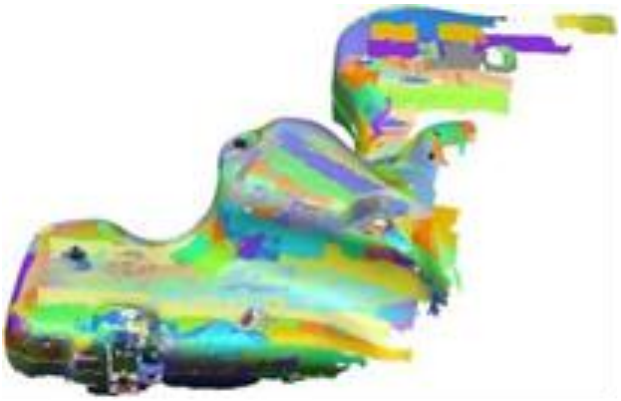

Fig. 4 *I st partial scan of petrol tank.*

The 2nd scan is an opposite side of I st scanned part of component (Fig.5).

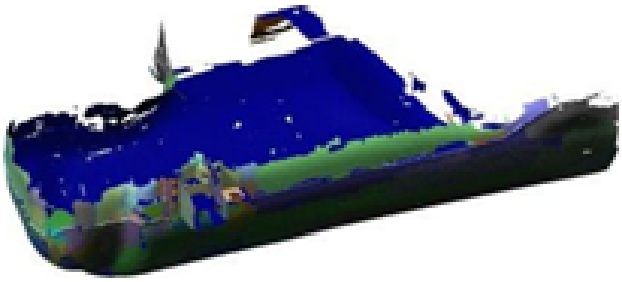

Fig. 5 *2nd partial scan of petrol tank.*

Using predetermined best-fit surfaces, we align these two scans through n-pairs of points (Fig.6). Through the use of this method we we'll obtain a larger unit (Fig.7).

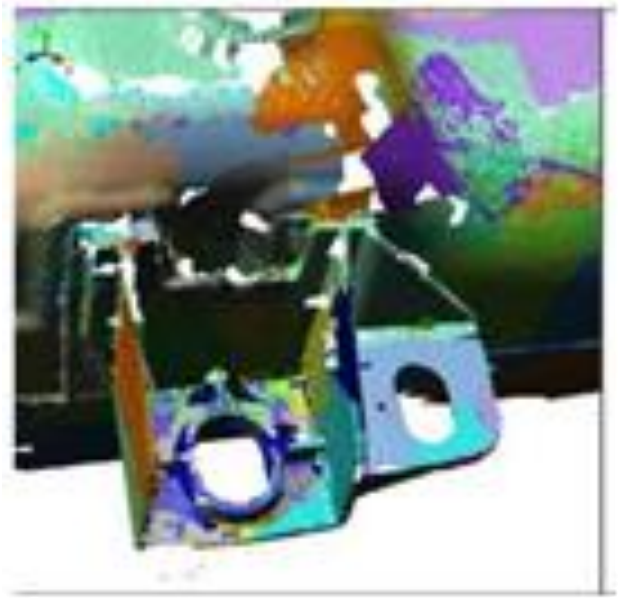

Fig. 6 *Best-fit with n-pair of point.*

Fig. 7 *Unit made by best-fit operations (after points reduction).*

Using these methods we were able to made all another parts of fmal scan. Total number of partial scans was 10 (Fig.8).

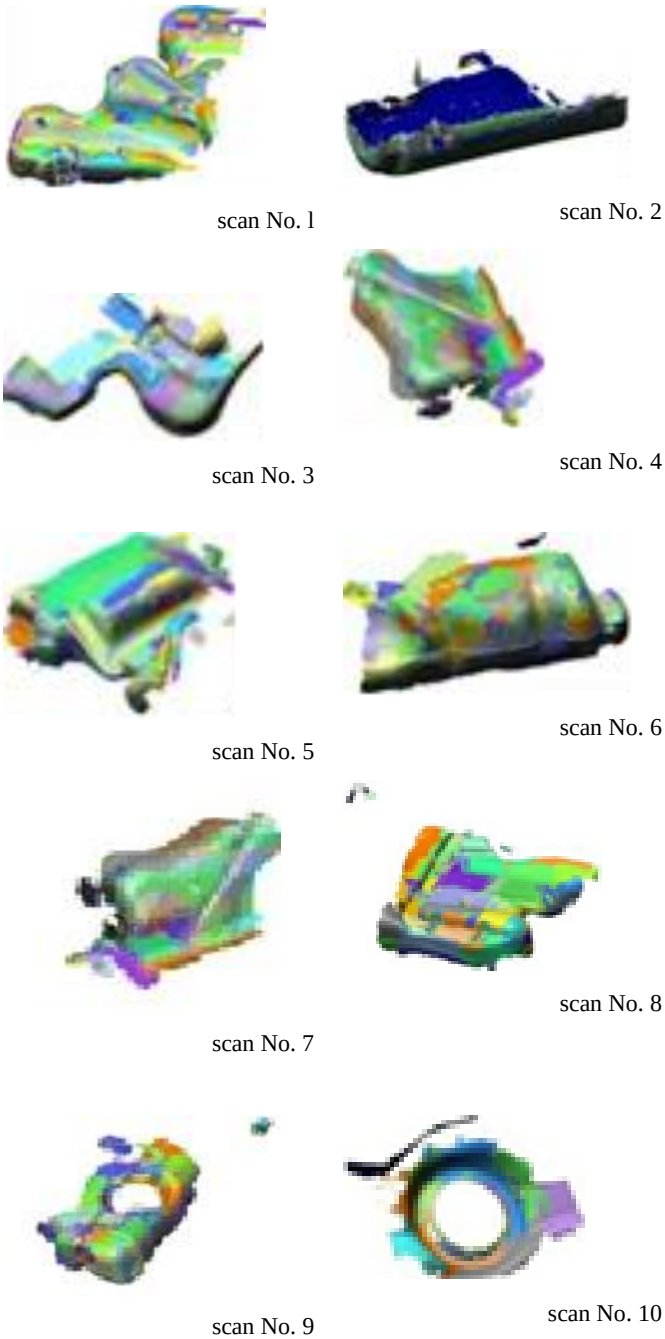

Fig. 8 *Partial scans of petrol tank prepared for best-fit.*

By using the best-fit operations we obtain step by step complete 3D scan of petrol tank. One of the last operations is points overlay reduction (Fig.9).

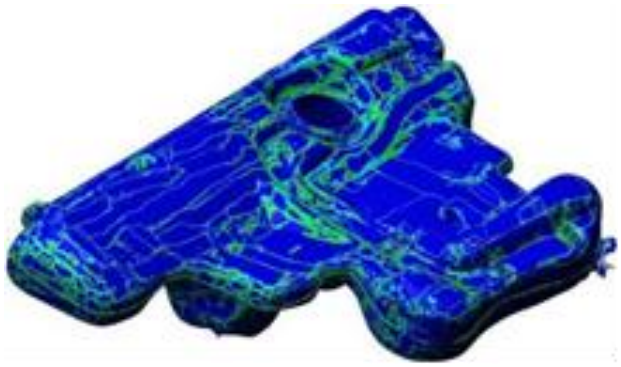

Fig. 9 Points overlay reduction.

Table 1: *Properties of 3D scan of petrol tank.*

Number of partial scans	**10**
Number of scanned parts	**1468**
Total number of scanned points	**14 146 823**
Number of points after points overlay reduction	**22041176**

Points cloud prepared like that is ready to use or export to some CAD software like for example CATIA ant for further modifications.

Fig. 10 Final points cloud (3D scan of petrol tank).

With use of partial scans connecting methods it 's possible to scan also objects or components which are larger than possibilities of scanning equipment. However, this method of producing 3D scans is also available for scanning of smaller components. It can be used for example for

3D scanning of surface parts, which can 't be scanned per one operation and so the component must be moved before scanning another part of surface.

It 's possible to fill up missing parts of surface of scanned component or to make some simple repairs of points cloud. [4]

3. Conclusion

The possibilities of using 3D scanning equipment and experiences with these tools are proving that digitizing is a tight part of product design processes and production. Experiences with 3D scanning equipment show us their high potential in mechanical industry but also in other branch of science. Problems that were introduced in this paper are solvable and results after solving are capable for mechanical industry demands.

Even large components and complex shapes can be digitized in parts. It is important to assemble the individual scans correctly so that they geometrically connect to each other. The joining of adjacent surfaces of the point cloud is based on interpolating the same geometry on two adjacent scans and recalculating its new position through the Best-fit operation.

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