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AN APPLICATION OF REVERSE ENGINEERING IN CONCURENT ENGINEERING

APLIKACE ZPĚTNÉHO INŽENÝRSTVÍ V SOUBĚŽNÉM INŽENÝRSTVÍ

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Abstract

The reverse engineering, which is one of the research development works at the companies provides decreasing product development time. Thus, products can be developed faster, cheaper, and more qualified. It has been commonly needed in product development process due to all of these reasons. In this study, reverse engineering procedure consisting of six stages, and used hardware and software are given with an illustrative example, and compared with traditional one.

Key words: design, reverse engineering, 3D scan

1. Introduction

Reverse engineering is a procedure for re-manufacturing or developing an object by analysing the entire manufacturing process and collecting the design knowledge of existing part or assembly. Reverse engineering is also considered as a method which has various legal use in product development. The term "reverse" used here comes from bidirectional data transfer between digital media and actual status [1].

Data of scanned objects are transferred to the CAD environment before manufacturing analysis and adjustment design process takes shorter time compared to traditional method. Some manufacturers generally need CAD data of parts or components included in new products. This necessity may be various reasons.

In this study, reverse engineering procedure has been discussed to get CAD data part of a machine, and an illustrative example modelling has been done by using reverse engineering software to explain the subject.

2. Reverse engineering procedure

Reverse engineering is needed in product development procedure reasons described as follows. Limited research concerning reverse engineering has been done in literature. Reverse engineering procedure is discussed in detail studies that have been done [1-6]. Usage of reverse engineering is inevitable in cases of the manufacturer intending to re-manufacture a part that has not been manufactured in a long time; having insufficient original design data or the original design data getting lost or being inexistent; original manufacturer not being able to meet the demand of the customer at the moment, or original manufacturer overpricing.

In addition to these reverse engineering procedure can also be employed when the need of re-design for eliminating the negative features of product, a requirement to strengthen the positive features in order to lengthen the lifetime of product or want to analyse positive and negative features of rival products and development of better competition based comparison methods arise. Another case of the usage of reverse engineering is when old parts or manufacturing methods are to be replaced with more current, cost effective counterparts, or when the old CAD model is inadequate for updates or current manufacturing methods.

3. Comparison of traditional and reverse engineering design procedures

When traditional and reverse engineering design procedures are examined in detail, it can be seen that they are completely different from each other. The number of traditional design process step varies between 4 and 25. For example minimum 4 digits design phase consist of; definition of requirements, design idea, prototyping and testing, and manufacturing steps. On the other hand, reverse engineering design procedure usually consists of 6 steps; acquisition of the reference product, three dimensional digitizing, design optimization, dimension and tolerance analysis, prototyping and testing, and manufacturing [2].

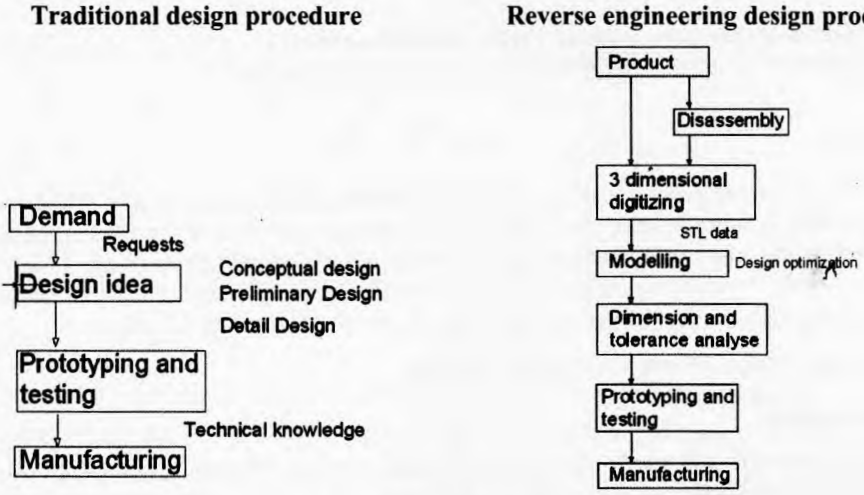


Fig.1 Traditional and reverse engineering design procedures

Compared to the traditional method, the pros of reverse engineering are as follows: the processed data can easily be transferred to CAD software and following product development processes and feasibility studies can be done in a short time span, scanners allow for through geometrical controls of objects, high density three dimensional scan data provides ease for industrial product design and quicker and more accurate test procedures. Reverse engineering procedure consists of the following steps:

Disassemble stage: If the old product which is subject to reverse engineering, is a complex system with many components, this system can always be separated to less complex components for ease of analysis. In such a case each component has to be modelled separately. In this study, the object can be modelled as a single part and the disassembly step is skipped.

Tree dimensional digitizing: It is possible to gather the point data belong to model one by one or without interruption automatically with the use of digital imaging techniques [3].

Design optimization: Design optimization is the remodelling procedure for the point cloud data introduced to reverse engineering software.

Prototype and test: This stage includes producing a prototype which is very similar to final product used to verify the design. In this stage, the possible flows in design can be corrected with necessary adjustment prior to manufacturing. (The verified design is ready for manufacturing).

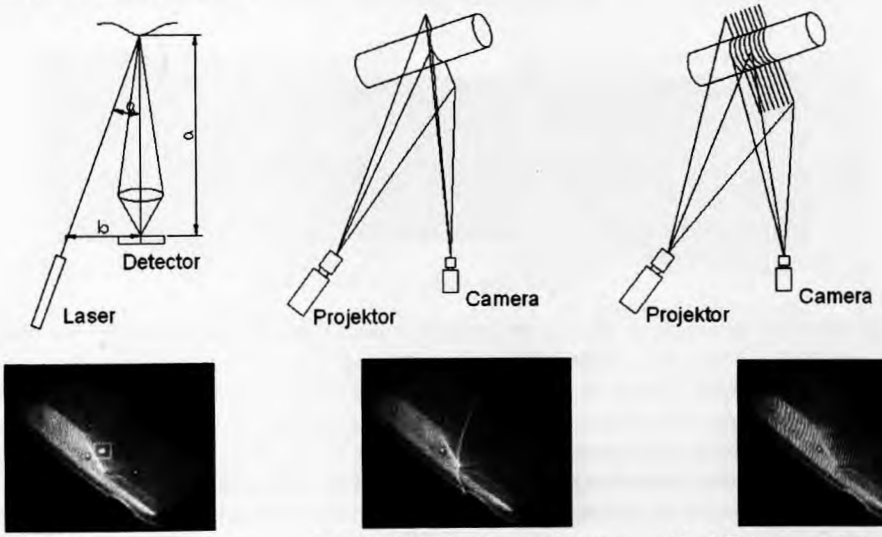
4. Digitizing in reverse engineering

Three dimensional digitizing process is a method to obtain three dimensional computer model from existing part. This raw information which is obtained from parts, can be utilized for the advanced level of product development process by reverse engineering software and applications [3]. Reverse engineering allows gathering point cloud data that belong to a part and hence creating CAD model by applying three dimensional digitizing techniques. Reverse engineering applications are widely available especially in the analysis of the problem encountered in manufacturing process [4]. The object scans by one or more camera in three dimensional scanning. Then it transfer three dimensional coordinate system. The object's references or surfaces and forms can be possible to measurement in the form of point cloud with the help of the computer. Optical measurement is divided into active and passive methods. Active methods consist of optical triangulate, light sectional techniques, fringe projection techniques. The following include basic information about these techniques.

Optical triangulation: A laser pointer and optical detector are arranged in a triangular structure. The distance of the point marked with laser, called triangular reference point, is determined by the detector (Figure 2.a).

Light section technique: Light section technique is an improved version of the optical triangulate. In this technique with help one line on the object and optical detector can obtain three dimensional profile in plane (Figure 2.b).

Fringe projection technique: Fringe projection technique is an improved version of the light section technique. Can be obtain three dimensional surface information by reflect multiple light section (white and black strips) pattern surface of the object with the aid of one or more high resolution cameras (Figure 2.c).



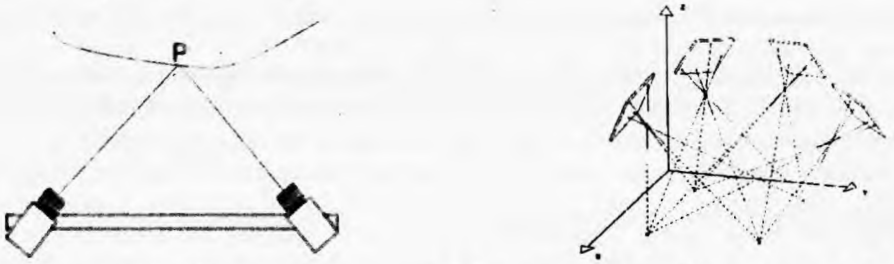
(2.a) Optical triangulate (2.b) Light section technique (2.c) Fringe projection technique

Fig.2 Active optician measurement techniques

Passive methods are consists of stereometri and fotogrametri. The following, include brief descriptive knowledge about these methods.

Stereometri: On the object of measurement to be made, doesn't reflect any light section. Instead of objects three dimensional surface to obtain overlap images taken from two cameras (Figure 3.a).

Fotogrametri: In this method scanned object imaging different angle with a camera with the aid of the indexmarks on the object, obtaining three dimensional point clouds in computer environment (Figure 3.b).



3.a Stereometri with two cameras 3.b Fotogrametri from different angle with one camera

Fig.3 Passive optical measurement techniques

5. Software used for reverse engineering

Can be obtain high sensitivity and quality CAD model by using three dimensional scan data with reverse engineering software. The software can also used with digitizing system for obtain more advanced level solution. Used in major software in reverse engineering are, CappsNT, Geomagic Studio, RapidForm, CopyCAD, Imageware and CATIA [5]. In this study modelling was done using RapidForm software. RapidForm is a standard software for reverse engineering and three dimensional scanning data process, it is preferred because of high operation capacity and user-friendly interface.

6. Reverse engineering application

A damaged hubcap has been taken up as procedure of reverse engineering application. First of all this damaged hubcap will be digitizing then described reverse engineering steps will be followed.

Fig.4 The images of the hubcap

In the first operation as shown in figure.4 broken hubcap being brought into the appropriate format, point cloud data have been obtained with three dimensional scanning device. Usually the object color must bright or must be painted with a bright paint for scanning device to detect an object to be scanned. The objective here provides the object distinguish other object and thus obtained more clear data. Three dimensional scanning technology in a large number of different specifications are available. In this study used three dimensional scanning device is stereSCAN brand device. The reason of use this device in reverse engineering activities and the specific features of this device are as follows.

- Allows for different viewpoints with a single bar by an adjustable lens range and provides 1,4 million pixel resolution in a single picture with two high resolution (6,6 megapixel) digital cameras.
- To give opportunity take point from different field of view with two cameras at the same time, and to provide ease of data acquisition for depth measurement.

- To provide opportunity alignment, pairing with the aid of indexmarks or object geometry method.
- Can create data files in format ASCII, Binary, STL

In the second stage, point cloud which taken from three dimensional scanning device open in RapidForm as STL format. Because of several reason in three dimensional scanning device, point cloud data may be inappropriate, incomplete or more. In these cases, can be done desired changes by using mesh module. When there are missing point or unwanted point, can be done additions or deletions by user. It is possible to do automatically, but can distorted of the original point.

Fig.5 The image generated from the point cloud data

In the third stage, obtained point cloud, automatically separate regions in "Region Group" module to help solid modelling (see Figure.6). This module given opportunity separate the model geometrical shape or freeform. After separate region begin modelling process, firstly surface is defined, then to create solid model with command of solid modelling

6(.a) After separate region

6(.b) Final solid model

Fig.6 The image of hubcap

In the final operation stage, the software does tolerances analysis within tolerance limits of the point cloud automatically using different colours. Admitted ±0.1 tolerance limits to the example of in this study and zones of valid this tolerance are shown in green (dark colors) as illustrated in Figure 7. Deviation of tolerance limits are represented different colors.

Damaged hubcap's missing parts are seen as if non-tolerance. Missing parts on the STL data file are represented non-tolerance. This regions meaning doesn't incorrect data, indicates missing data. Thus solid model is completed and existing part transferred digital media. Saved the file in the format XRL can be used to CAE and structural analysis and other CAM.

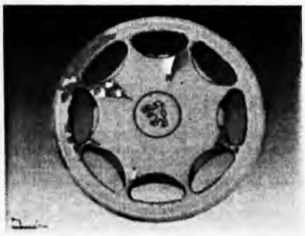


Fig.7 The image of tolerance analysis

7. Conclusion

In this study, reverse engineering procedure are discussed in detail with an example. This study has been shown CAD data which cannot be obtained easily with existing design method can be provided fast and precise. Knowledge has been given about reverse engineering stage and used software and hardware.

References

[1]. Ping Fu, Reverse engineeringin the automotive Industry, Reverse Engineering An Industrial Perspective (Editör V.Raja, K.J.Fernandes) , Springer Series in Advanced Manufacturing, London, pp.141-155.

[2]. DHİLLON, B.S.; "Engineering And Technology Management Tools And Applications", Artech House Inc., London, 2002 211-225

[3]. Akdoğan, A., Görür, B.V., Yurci, M.E., Durakbaşa, M.N., "Comparsion of Coordinate Measuring Machines Digitizing Capability and an Optical Digitizer",Wesic 2003, 4th Workshop on European Scientific and Industrial Collaboration, Session WS3C, pp.261-269, Dubrovnik, Hırvatistan, May 28-30, 2003.

[4]. Broggiato, G.B., Campana, F., Gerbino, S., "Shape deviation Analysis on Sheet-Metal Parts Through Reverse Engineering Techniques", XII ADM International Conference, Rimini, İtalya, Sept. 5th-7th, 2001. D3-11 – 3-20

[5]. Ngozi Sherry Ali, Reverse engineering of automotive parts alpplying laser scanning and structured light techniques, Master Tezi, The university of Tennessee, Knoxville, 2005.

[6]. Schankovsky, C., Ganea B., Raveica C., Herghelegiu, E., Reverse engineering for automotive industry, Annals of the Ordea University, Vol.VII, 2008, pp.1770-1774.

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