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DEVELOPMENT OF COMPUTATIONAL MODEL THROUGH REVERSE ENGINEERING: CAR SIDE MIRROR CASE STUDY

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DECLARATION

"I hereby, declare this thesis is result of my own research except as cited in the references"

Signature	:………………………..
Author's name	:………………………..
Date	:………………………..

DEDICATION

For my Dear Parents

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Apart from that, I would like to take this opportunity to express my heartfelt thanks to technician who give advice to use machines at FKM lab and FKP lab. I am very grateful to receive the sharing of experience and the skill of using the machine from them. In addition, I would appreciate librarian and library's staff for arrangement and service given.

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ABSTRACT

The study of development of computational model through reverse engineering is an effort to understanding the reverse engineering. It concentrates to difference method of reverse engineering between conventional data and 3D scanning data. The role of reverse engineering which is important in industrial is been identified. Furthermore, it also studies the technology of rapid prototyping development, rate of using rapid prototype in industrial technology century nowadays. The aim of this case study is to differentiate the 3D model of conventional method and 3D scanning method. Then, data of 3D scanner drawing is exchanged for rapid prototype purpose. Two prototypes have been created using existing car side mirror through conventional data drawing and 3D scanner drawing. From this, the difference dimension and process between the 3D model of CAD drawing and 3D scanner is observed. Moreover, it can provide difference between two prototypes of side mirror through reverse engineering and existing product. Then determine the appropriate method between conventional and 3D scanning method for reverse engineering. This study assists to discover the process of reverse engineering by experience of drawing, using 3D scanner and machine rapid prototype.

ABSTRAK

Kajian pembangunan model berkomputer secara kejuruteraan balikan adalah satu usaha untuk pemahaman kepada kejuruteraan balikan. Ia tertumpu kepada perbezaan antara data konvensional dan data 3D pengimbas. Pengetahuan terhadap kejuruteraan balikan adalah penting di industri sekarang. Tambahan pula, ia juga mengkaji teknologi pembangunan pencontoh sulungan cepat, kadar penggunaan contoh sulung yang pesat dan dalam industri pada abad teknologi sekarang. Matlamat kajian kes ini adalah untuk membezakan 3D model dengan kaedah konvensional dan kaedah 3D pengimbas, kajian bertukar data 3D pengimbas untuk tujuan manghasilkan contoh sulung. Perbandingan dimensi contoh sulung yang dihasil dengan wujud cermin pandangan sisi sebuah kereta sedia ada daripada data 3D pengimbas dan data konvensional. Kajian ini boleh membuktikan kaedah konvensional atau kaedah 3D pengimbas adalah kaedah yang paling sesuai untuk kejurutearaan balikan. Selepas menyempurnakan projek ini, kemahiran lukisan, menggunakan pengimbas 3D dan mesin pencontoh sulungan cepat akan didapati, dan boleh menangani proses kejuruteraan pembalikan.

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LIST OF ABBREVIATIONS

RE	=	Reverse engineering
CAD	=	Computer-aided design
CMM	=	Coordination measurement machine
CFD	=	computational fluid dynamic
FEA	=	finite element analysis
RP	=	Rapid prototyping
CAID	=	Computer-aided industry design
LM	=	Layer manufacturing
CATIA	=	Computer Aided Three Dimensional Interactive Application
STL	=	Stereolithography
Prototype A	=	Prototype using conventional method
Prototype B	=	Prototype using 3D scanning method

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Reverse Engineering (RE) is a process of discovering the technological principles of a device, object or system through analysis of its structure, function and operation. It often involves taking something apart and analyzing its workings in detail. As computer-aided design (CAD) has become more popular, reverse engineering becomes a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD, CAM, CAE and other software.

Reverse engineering process involves measuring an object and reconstructing it as a 3D model. Measured data itself usually is represented as a point cloud, and it is normally lacking of topological information and therefore often processed and modeled into a more usable format. After then, it is continued with use of software for data exchange to produce a rapid prototype. Comparison between conventional drawing data and CAD reverse engineering data will show that technology nowadays is fast, rapid and a leap forward compared to days without concept of reverse engineering.

Reverse engineering and rapid prototyping is now entering the field of rapid manufacturing, and it is believed by many experts that this is a "next level" technology. The skill of rapid prototyping is important for current technology application.

1.2 Problem Statement

Many industries have felt the importance of obtaining important information from the physical shape of an object. Diversity of items which requires measurement is huge; however, their shape properties can be broadly classified into two main categories, they are the regular, consisting of planes, cylinders and so on, or free-form, where the shape of the surface is considerably more complex to describe. Two of the most common uses of surface shape information are for inspection to enable the comparison of original object geometry with the one reverse engineered, and determination of object geometry where no nominal data exists.

There are many instances in which one may need to create a CAD model starting from an existing prototype: Old part design, Worn or Damaged Parts, Inspection, Replicating Components Acquired in War.

There is few method of reverse engineering such like scanning and conventional method. However, these two methods have their advantages and disadvantages on certain process.

1.3 Objectives

The objectives of this project are as below:

1. To study reverse engineering techniques which enable the comparison between conventional methods and 3D scanning method on side mirror of Proton Wira.
2. To development a computational model for a car side mirror through reverse engineering technique.
3. To fabricate a rapid prototype using reverse engineering technique.

1.4 Scope

1. Literature review on existing design of side mirror
2. Study and analyze Proton Wira's side mirrors.
3. Construct 3D model of existing product using conventional methods.
4. Develop 3D model using 3D scanning method.
5. Transfer data into rapid prototyping machine.
6. Produce rapid prototypes using RP machine.
7. Compare the existing model and rapid prototype model, and followed by making a justification.

1.5 Limitation

- Only allow to use machine provided by UTeM.
- Case study conducted is analysis is limited to one type of the side mirror only.

1.6 Expected Result

Expected result mainly covers the differences of 3D model of CATIA drawing and 3D scanning drawing. Comparisons include the aspect of dimension, shape, skill to obtain the drawing's data, and accuracy of drawing. Technique to obtain data by using 3D scanning is better than conventional method, because it is far more reliable. Furthermore, comparison between rapid prototype and existing product shows that aspect of the shape and dimension of prototype are similarly justified to original object. Besides, data exchange from 3D scanner will be performed by using correct software, it is converted and adapted for rapid prototype machine use and furthered fabricates a side mirror prototype. Prototype will be fabrication and the shape should be almost the same as the existing product. Skill of reverse engineering like CAD drawing, technique of using 3D scanner, and rapid prototyping machine is mastered upon the finish of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Reverse Engineering

Reverse Engineering (RE) is the process of discovering the technological principles of a device, object or system through analysis of its structure, function and operation. It often involves taking something apart and analyzing its workings in detail to be used in maintenance or to try to make a new device or program that does the same thing without copying anything from the original.

As computer-aided design has become more popular, reverse engineering becomes a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD [computer-aided design], CAM, CAE and other software. The reverse-engineering process involves measuring an object and then reconstructing it as a 3D model. The physical object can be measured using 3D scanning technologies like CMMs, laser scanners, structured light digitizers or computed tomography. The measured data alone, usually represented as a point cloud, lacks topological information and is therefore often processed and modeled into a more usable format such as a triangular-faced mesh, a set of NURBS surfaces or a CAD model.

The point clouds produced by 3D scanners are usually not used directly since they are very large unwieldy data sets, although for simple visualization and measurement in the architecture and construction world, points may suffice. Most applications instead use polygonal 3D models, NURBS surface models, or editable feature-based CAD models. The process of converting a point cloud into a usable 3D model in any of the forms described above is called "modeling"'.

2.1.1 Technology

Reporter Dean Palmer (2005) wrote that John Myers, CAD system manager at Dyson commented:" Our conceptual designs are produced in 3D, which has fantastic benefits, Rather than just producing view of products, you design the real thing. This reduces ambiguity and often makes it easier to understand complex assemblies. You get a lot of feedback, seeing it coming together before your very eyes."

"We do still use CFD, FEA and other simulation tools to optimize designs, but we like to make something and physically test it. You can see and understand something much better by trying it, rather than simply relying on numerical software. We use lots of new materials in our product and so we prefer to test physical prototypes. Even in concept design, we prefer to sketch by hand on paper. Some 2D or 3D sketching is done on the PC, but a lot is done by hand," he added.

XJ Cheng (2006) said that 3D laser scanning technology can measure 3D coordinates point on object surface. Therefore, it belongs to three-dimensional measurement technology. Compared with the traditional surveying method, laser scanning technology has particular superiority as follows:

- is a sort of untouched measure system;
- gain the 3D coordinates, reflecting intensity etc. on object surface;
- rapidity of data acquisition, great quantity of data and high accuracy;
- work under all kinds of environments;
- extensive application.

Varady T (1997) using 3D point data collected by contact or non-contact method, a CAD model can be created and employed in subsequent manufacturing processes. An in depth review of reverse engineering.

A reverse engineering technology with a difference has been developed in which items can now be accurately laser scanned to obtain their dimension in 3D, as well as their visual appearance, including color. The system may also be used for medical purposes and for the recording of art and antiques

Reporter Kestrel wrote that scanning accuracy, according to general manager, Peter Wilson, is down to eight microns, but what really sets the machines apart from their competitors, is their incorporation of red, green and blue channels I the laser light scan, and the capture of color by the CCD camera. The largest machine currently in the company's possession can scan object up to 2.5 m long and 1.2 m wide and high.

2.1.2 Reverse Engineering based on Haptic Method

Zengyi et al. (2005) noticed a new reverse engineering is based on haptic volume removing. Now digitizing the physical object is by simply chipping away the virtual clay with a position tracker that is attached to a haptic device PHANToM as shown in Figure 2.1.

The physical object to be digitized should be solid and impenetrable because there is physical contact between the position tracker and the object. This requirement indicates that the proposed method cannot work well on soft object.

The haptic force is important while sculpting as the virtual clay surrounding the physical object in invisible, a sense of touch gives the user as to which part is yet to be removed.

The PHAMToM hardware design is the same as that of the commercially available articulated type of the manual digitizing system. Point cloud collected by this type of digitizers normally contains many noises due to the clumsy manipulation. The user has no idea about which part has been digitized which has yet to be digitized, especially when the contact between the probe and the object is interrupted. From the point cloud, it is difficult to identify which parts have been digitized and which have yet to be done.

Then by definition of virtual clay that is enclosing the object in the proposed method. While sculpting on the virtual clay, the object can be seen emerging as an unambiguous volume model.

Vergeest JSM (1999) said that the process of generating a computerized representation of an existing part is known as reverse engineering. Unlike the traditional manufacturing philosophy of design being transposed into product, reverse engineering measures, analyses, modifies, and produces the product based on existing artifacts.

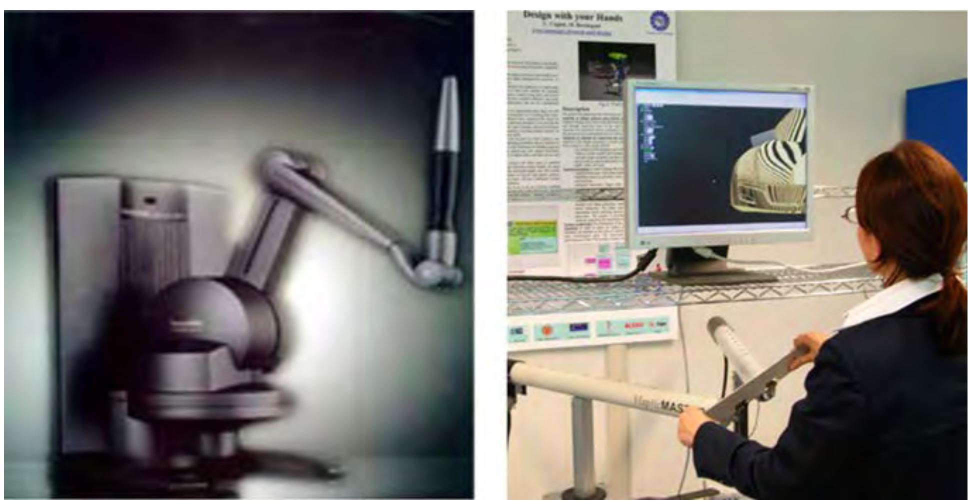

Figure 2.1: Haptic device and haptic modeling interface

(Source: Xiuzi Ye, 2007)

2.1.3 Reverse Engineering Process

Fisher RB (2003) says that the goal of RE is to generate a CAD model from measured data of a physical model as a replica of the original one, and pass the CAD model to CAE and CAM. RE is widely used in such fields as industrial product design, commodity design, toy design and plastics. In RE, significant differences can exist in the requirement of the design and expression of forms, due to the distinct characteristics of products and different source of input data. RE involves the following steps:

(i) 3D scanning of physical projects, typically generating a point cloud. Most scanners nowadays have embedded point cloud processing and meshing software to output mesh models.

(ii) Data processing such as noisy data removal, registration, sampling, smoothing, topology repair and hole-filling.

(iii) Surface reconstruction from mesh or point cloud by direct surface fitting or surface reconstruction through curves such as section curves and feature lines.

The results of RE are usually surfaces that need to be imported into 3D CAD software. Modelling operations including surface extension, trimming and sewing are performed to form solids for downstream operations such as CAE analysis and RP.

Sarkar and Menq et al (1991) define the steps to follow in a reverse engineering process. The process begins with a scan of the surface points and the detection of the limits of each region or type of surface. These limits allow the point cloud to be divided into different regions. Subsequently, in each region, the x,y,z coordinates of the points are transformed into u,v, parametric values, the nodes are selected, and an iterative least-squares B-spline surface approximation is applied to the point cloud in each region, until the error falls below a given tolerance. On occasions, it is necessary to subdivide the