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Review Paper on Reverse Engineering

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Abstract—*This paper presents the review of reverse engineering. The purpose of article is to introduce reverse engineering procedure, what we need to do this kind of procedure and how we can remanufacture any product. The purpose of reverse engineering is to manufacture another object based on a physic and existing object for which 3D CAD is not available. It is the method that reconstructs CAD models from physical models. The mainprocess of reverse engineering consists of data acquisition, data pre-processing, surface fitting, and making a CAD model. In reverse engineering, we mainly handle point data of the surfaces of a model acquired by measuring devices such as CMMs or 3D laser scanners.*
Reverse engineering is a kind of engineering which takes advantage of an already created object. The final purpose is to create another object similar to the existing object. Getting this is essential to get information about the physic object. Reverse engineering can be applied in different fields like software, electronic components, big pieces, small pieces. In this paper we presents reverse engineering which is focused on objects. This method is the most used.
Today, the RE technique is commonly applied in many fields: manufacturing engineering, software engineering, film-entertainment industry, chemical engineering, electro technical industry, and recently there are first examples have come forth regarding RE application in industry of Micro-Electro-Mechanical Systems (MEMS).

1. INTRODUCTION

Engineering is the profession involved in designing, manufacturing, constructing, and maintaining of products, systems, and structures. At a higher level, there are two types of engineering: forward engineering and reverse engineering.

Forward engineering is the traditional process of moving from high level abstractions and logical designs to the physical implementation of a system.

Reverse Engineering: In some situations, there may be a physical part without any technical details, such as drawings, bills of material, or without engineering data, such as thermal and electrical properties.

The process of duplicating an existing component, subassembly, or product, without the aid of drawings, documentation, or computer model is known as reverse engineering.

Reverse engineering can be viewed as the process of analyzing a system to:

1. Identify the system's components and their interrelationships

2. Create representations of the system in another form or a higher level of abstraction

3. Create the physical representation of that system

What is Reverse Engineering and how it is implemented in product manufacturing?

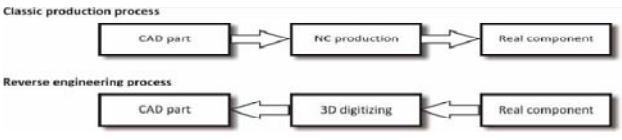
What are the advantages of Reverse Engineering in industrial manufacturing?

Reverse engineering is the reverse process of the design activity. It basically consists on the reconstruction of design models associated to a real product. The main goal of the reverse engineering is to go back to the results of the original design process in order to create a copy of the product,

Reverse engineering has been developed as an alternative solution to define or redefine objects. Nowadays, it is widely spread in the manufacturing industry. It is used for the capitalization of information and knowledge, which haven't been collected yet. This is a critical issue for the development and evolution of products. We can list some of its applications in industry: long life products maintenance (trains, boats, aircrafts, nuclear power plants, etc.), redesign of existing products in order to improve them, competitor's product's analysis.

Reverse engineering application in automotive industry is integral part of car creation processes. 3D scanners are most used by design part of car. It would be time-consuming and difficult to transfer real designer's car model into 3D CAD model without 3D scanning. This process decrease to minimum with help of 3D scanner technologies and the designer can transfer his design in few minutes to CAD software.

Classic machine process begins from CAD model and ends by component production. RE process is opposite. At the beginning is real component and it ends with digital model



Reverse engineering is a very important branch of geometrically design and manufacture application area, and this technique has been widely recognized as being an important step in the product development cycle. The use of RE will largely decrease the manufacturing time and costs. RE is the process of producing design details in the form of CAD model from the physical part in the process of the product design. In contrast to the traditional production sequence, reverse engineering typically starts with measuring an existing object, so that a solid model can be deduced in order to make use of the advantages of CAD/CAM/CAE technologies. Afterwards, CAD models are used for manufacturing or rapid prototyping applications.

The applications of RE in the industrial area are defined in respect of following aspects:

- **Design of a new component**The design of new part comes from an existing real part model.
- **Reproduction of an existing component**Some parts exist for which no design/manufacturing documentation exists but its copy can be obtained by RE approach.
- **Produce a component of optimum quality and life** Sometimes the production rate of the production system is directly dependent on the strength and quality of the tool material. The shape of the component can be edited by using reverse engineering to get the optimum production rate.
- **Recovery of a damaged or broken component** If the surface of a part to be measured is damaged or worn away, the reconstructed CAD model may not be precise compared with the true surface of the part.
- **Development of model precision**The engineer can finish a product concept design based on the requirements of function and aesthetics and then use some soft materials, such as wood or plaster, etc., to fabricate models.
- **Observation of a numerical data**Scanning the part and reconstructing a 3D-CAD model by the RE approach, the designer can compare this model with the first model.

Following are reasonsfor which we should do reverse engineering of a product:

1. The original manufacturer of a product no longer produces a product
2. There is inadequate documentation of the original design
3. The original manufacturer no longer exists, but a customer needs the product
4. The original design documentation has been lost or never existed
5. Some bad features of a product need to be designed out. For example, excessive wear might indicate where a product should be improved
6. To strengthen the good features of a product based on long term usage of the product
7. To analyze the good and bad features of competitors' product
8. To explore new avenues to improve product performance and features
9. 9. To gain competitive benchmarking methods to understand competitor's products and develop better products
10. The original CAD model is not sufficient to support modifications or current manufacturing methods
11. The original supplier is unable or unwilling to provide additional parts
12. The original equipment manufacturers are either unwilling or unable to supply replacement parts, or demand inflated costs for sole source parts
13. To update obsolete materials or antiquated manufacturing processes with more current, less expensive technologies.

2. INNOVATIVE TECHNIQUES

Reverse Engineering consists of the following innovative techniques

2.1 Digitizing.
2.2 Segmentation of the acquired data.
2.3 Knowledge extraction (feature recognition).
2.4 Reconstruction of the 3D model

2.1 Digitizing

Digitizing processes allow us to transfer real part surfaces to digital form. Basic principle of digitizing is to scan the component in space points and getting the output in CAD software. Main type of digitizing processes is the 3D scanning.

The major system components in this process that used are the three-axes mechanical set-up, the probe head, control unit and PC.CMMs have become very powerful parts of measuring tools. The CMM is a Cartesian robot, which has a touch-trigger probe in place of a gripper. The main application software utilized is the Pro/Engineer Wildfire CAD/CAE/CAM integrated system.

In this process the physical object’s scanning is done with the help of scanner, which records the dimension and shape of the object and display it on the PC monitor in terms of point cloud. The point cloud is nothing but the combination of the major points on the surface of the object.

Hence in this process physical geometry of the product is converted into the 3D point cloud of the shape of the object.

3D scanning is a method which allows us transferring scanned points from space to CAD software and to utilize them. There are more types of digitizing devices that allow this transfer. Main types are:

- Optical
- Laser
- Contact
- Destructive4

2.2 Segmentation of the acquired data

The output data of the CMM are coordinate values of the center of the probe and normal vectors in the X, Y and Z direction at the position of the tactile point. Additionally, the output format ofthe measurement data does not accord with the requires of the generation of a CAD model. The format of the measurement data output must be transformed into a format and must be segmented into small parts that can be accepted by Pro/Engineer software. The data processed can be used directly for the creation of a CAD model of the part.

2.3 Knowledge extraction (feature recognition).

The CAD model is created directly from measurement datausing Pro/Engineer CAD/CAE/CAM software after processing ofmeasurement data and transforming of the data format. To modelthe part surface in CAD model we need to define surface features from the cloud of points obtained by digitization. The surface features contain surface segments and boundaries.

There are two methods in the creation of the CAD model from measurement data using free-form feature modeling. First method is called the curve mode. In this approach, the construction curves are generated from measurement data first, and then the surface can be created through the construction curve mesh generated. Another one is called the surface model, the surface is generated directly from measurement data by using points cloud.

Secondly, the created surface model of the part in PC-DMIS is imported to the Pro/Engineer CAD/CAM software. Finally, the surface model converted into 3D-CAD (solid) model.

We convert the point cloud in a solid 3D cad model. The idea is to draw a solid taking advantage of the mesh. At the end, the 3D solid has to look like the mesh. Other thing is that reverse engineering is always an approximation of the original piece, in other words, at the end our piece will be approximately the same that the original piece.

After this, we will be able to manufacture the piece in the machine of selective laser sintering.

2.4 Reconstruction of the 3D model.

To work better and easier, divide the component in two parts called upper part and lower part.

The mesh is not perfect, it contains some holes and some damages on the surfaces. But Solid Works software has a feature which helps to repair the mesh. It consists in filling the holes and to join the damages to the parts. At the end, the mesh looks much better than before and it is the updated version of the real component.

3. CONCLUSIONS

This paper presented a first prospecting of the integration of knowledge management approaches in a global reverse engineering methodology. The aim is to enhance the robustness of the reverse engineering process results. This work shows some possibilities of use and advantage from utilizing the RE techniques in manufacturing process, especially in those case for which there is unavailability of the product drawings, must be replaced and there is no source of supply. In this contest, RE is absolutely required because allows digitizing the part geometry to be utilized in CAD/CAE/CAM. In many cases documentation of mechanical components such as drawings, specificationsand engineering analyses are lost. It is often required to replaceworn or broken parts in which this documentation does not exist.In industry today, short lead-time is demanded because of the advantage of reverse engineering that it does not require any data for preprogramming of the design of the product since it uses the physical model of the product and converts.As a result application of RE approaches to gaining speed the product realization process is currently gaining momentum and largely decreases manufacture costs.

Further work will deal with the development of a methodology of reverse engineering, which will have the heterogeneous data as guidelines. This methodology will be based in order to extract knowledge from data and use it to reconstruct 3D parameterized models.

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