Reverse Modeling and Design of Radar Cat's Eye Based on GeomagicDesign

Xuzhao Han¹*, Lin Kong², Ying Jin¹ and Juanrong Zhang¹

¹ Xianyang Vocational Technical College, Xianyang, China
² Xi'an Aeronautical Polytechnic Institute, Xi’an, China

*Corresponding author email: xuzhao_han@163.com

Abstract. This paper takes the physical model of Radar Cat's Eye as the research object, based on geomagicdesign software’s powerful reverse modeling function, the reverse modeling and design process of Radar Cat's Eye is explained in detail. The detailed steps and main precautions of scanner calibration in the process of Radar Cat’s Eye reverse modeling are given. At the same time, the main contents of model scanning, data processing, reverse modeling, model comparative analysis and so on are also introduced and explained in detail. In short, the relevant contents of this paper provide reference and help for the reverse modeling and design of other models.

Keywords: Reverse modelling; GeomagicDesign; Model scanning; Data processing.

1. Introduction
Reverse design uses the software that can realize reverse 3D modeling design to reconstruct the 3D CAD model (surface model reconstruction), and based on the digital processing such as the data acquisition and the data processing of the physical surface sample of the product, and then the virtual prototype technology such as CAD / CAE / CAM is further used to realize the process of analysis, redesign, numerical control programming and numerical control machining.

Like the concept of industrial design, reverse engineering can realize product replication and product reproduction through the application of its own technology, so as to more optimize models and parts [1-3]. Generally, from reverse design to new product development, we have to go through the following processes: product sample, data acquisition, data processing, CAD / CAE / CAM system, model reconstruction, manufacturing system, and finally generate new products. Because reverse design has actual models to participate in various tests, it can effectively shorten the product development cycle, save the development cost, give full play to the creativity and imagination of designers, and is widely used in the design and manufacturing of aircraft, automobile, arts and crafts, mold and other industries [4].

As shown in Figure 1, this paper take the radar cat's eye as the physical model, it discusses the reverse modeling process of the component based on GeomagicDesign software.
2. About GeomagicDesign Software
GeomagicDesign is a forward and reverse modeling software launched by Geomagic company. It is the only 3D design software in the industry that combines real-time 3D scanning, 3D point cloud and triangular mesh editing functions, as well as comprehensive CAD modeling design, assembly modeling, 2D engineering drawing and other functions. The software reflects the latest development trend of reverse engineering technology. At present, it has become the first software promoted by Geomagic company and has been more and more widely used in enterprises and academic circles at home and abroad [5-7]. GeomagicDesign X combines feature-based CAD modeling and 3D scanning data processing, and can create editable and feature-based CAD modeling, which is compatible with existing CAD software [8,9]. GeomagicDesign X can directly create models from damaged or impurity containing scanning data. The edited solid models can be used in 3D printing, mold design and manufacturing, NC machining and other fields.

The software is powerful, easy to operate and easy to learn. It is especially suitable for engineers and technicians engaged in reverse engineering applications [10], and so, based on this software, the author completes the reverse modeling and design of Radar Cat's Eye.

3. Scanning System Calibration
In reverse engineering modeling, scanning the original model is the first step, and calibrating the camera parameters is the basis of the accuracy of the whole scanning system, so the scanning system must be calibrated after installation. After calibration, if the calculated error result is too large to meet the requirements of calibration accuracy, it needs to be calibrated again.

Figure 2 shows the scanning software and hardware system adopted in this paper. The scanning software is GeomagicWrap of Geomagic company, and the hardware is Win-3D series structured light 3D scanner of Beijing 3D world Technology Company. The scanner uses grating scanning technology and automatic splicing of marker points. It has the advantages of high efficiency, high precision, high service life and high resolution. It is especially suitable for reverse modeling of complex free-form surfaces.

When the scanner is calibrated, first start the Wrap –Win-3D scanning system, enter the software interface, adjust the scanning distance, and make the two crosses of the software interface coincide as much as possible. Then, the parameter calibration is completed by adjusting the placement angle, scanning distance and pad angle of the calibration plate, so that the average error of the calibration result is controlled within 0.028 mm, otherwise it is recalibrated.

Figure 1. Radar cat’s eye physical model.
In the calibration process, in addition to strictly following the calibration steps, special attention should be paid to randomness when pasting the marked points on the calibration board, so as to avoid marking as regular geometry as far as possible.

4. **Radar Cat's Eye Scanning and Data Processing**

Before the Radar Cat's Eye scanning, first complete the preparation work such as cleaning and powder spraying, the powder spraying distance is about 30cm, and spray thin and cut evenly as much as possible. Obtaining point cloud data by scanning is the key process of reverse modeling, so the basic requirements for scanning cases are: the point cloud is complete; miscellaneous points and noise points shall be minimized; the distribution of point cloud shall be as regular and smooth as possible; retain its original features.

After the scanner completes calibration and makes relevant preparations, it can scan the Radar Cat's Eye and collect data. Generally, the scanning process is: new project → place scanning workpiece → adjust camera parameters → start scanning → rotate the calibration plate to scan different faces and viewing angles → change the placement orientation → repeat scanning → check scanning integrity → save and process point cloud data.

![Figure 2. Scanning software and hardware system.](image)

![Figure 3. Radar Cat's Eye point cloud data.](image)
In this operation, GeomagicWrap software is selected for 3D scanning data conversion, which has strong point cloud processing ability and can quickly complete the fitting from point cloud data to triangular patches. In this paper, the effect of the Radar Cat's Eye scanning and data processing is shown in Figure 3.

5. Radar Cat's Eye Reverse Modeling

In this paper, GeomagicDesign software is used for reverse modeling and design of the Radar Cat's Eye model. Firstly, the Radar Cat's Eye.stl file obtained above is imported into GeomagicDesign software, and the relevant basic features are generated by using the menu of patch stretch, fillet and shell. Then click the domain menu to complete the creation of domain surfaces, create the contour surface of the Radar Cat's Eye by using the menu of patch sketch, 3D sketch, stretch and rotation. Then click the cut surface menu to carefully complete the cutting of redundant non contour surfaces, and then materialize the surface features of the upper and lower parts of the Radar Cat's Eye part through commands such as surface offset, surface filling and surface extension. So far, the basic solid model of the Radar Cat's Eye has been completed by GeomagicDesign software. In order to more approximate the relevant parameters of the solid model, operations such as cutting, rounding, Boolean operation and so on must be carried out. It should be noted that in GeomagicDesign software, you can view the accuracy of modeling through deviation preview while modeling. The reverse modeling effect completed by GeomagicDesign software is shown in Figure 4.

6. Generation Comparison Report

When reverse modeling is completed, it is also necessary to quickly detect the difference between CAD model and actual model to determine the accuracy of reverse modeling. In this paper, Geomagic Control software of Geomagic company is used to detect the CAD model generated above. Firstly, import the Radar Cat’s Eye.stl file of point cloud data after Geomagic Wrap processing and the Radar Cat’s Eye.stp file of CAD model after GeomagicDesign modeling at the same time, set the test part and the reference part, using the best fit method, move an object to another object and click 3D analysis to generate a color deviation diagram that distinguishes different colors between the test piece and the reference piece. Click 2D analysis to generate the color deviation diagram on each cutting plane, and finally click generate analysis report. The report contains test data, multiple views, comments and other results. The comparison report of the Radar Cat’s Eye parts modeled in this paper is shown in Figure 5.
7. Conclusion
Reverse design has the characteristics of low cost, short cycle and easy innovation. At present, it is widely used in automobile, aerospace, arts and crafts and other fields. Geomagic series software is simple and easy to operate, and can quickly realize the reverse modeling and data analysis of solid model. Therefore, using GeomagicDesign software to complete the reverse modeling and design of solid model has its practical significance, and can quickly respond to the personalized needs of users. The modeling method and process in this paper have a certain reference value for reverse design.

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