

Application and Research of RE in AutoCAD System

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Abstract:

With the development of science and technology, the application of Reverse Engineering Technology Reverse Engineering in machinery and other fields has become the frontier science in the field of science and technology today. In order to improve the production efficiency and shorten the product development cycle, the processing of data on the basis of existing sample images has become an inevitable trend in the development of the mechanical field today. In this paper, we analyze the method of contour line tracing of the scanned drawing by applying the reverse engineering technology, and elaborate the design theoretical idea and its implementation process of the CAD 3D model system generated from the scanned drawing by using AutoCAD and VB.NET as the development environment. Combined with the scanned drawing of a mechanical part gear as an example, the scan drawing generation 3D modeling system is successfully used to realize 3D modeling.

Keywords: Reverse engineering, AutoCAD, 3D model, After exploitive of AutoCAD.

I. INTRODUCTION

With the development of science and technology and the improvement of production efficiency [1], manufacturing technology is also developing day by day, more and more product manufacturing requires a three-dimensional solid model of the parts for analysis and processing manufacturing [2]. However, many times the designers are frequently in the new and modified products, and the intermediate process is very complex, and the product types are too many, which causes the development cycle time is too long, the production efficiency is too low and other economic conditions [3]. For do not know the CAD model or design of the product parts, but only its various forms of physical models, physical samples or picture samples of similar products, so that if the processing or redesign on this basis, it is necessary to digital processing, the three-dimensional discrete data obtained as the initial material, with the help of a special CAD system and visible surface processing software to construct a three-dimensional model of the entity [4,5]. Using the output CNC machining instructions to drive CNC or STL files to drive rapid prototyping machines to manufacture a prototype of the product, this product development model is called reverse engineering or reverse engineering, or RE (Reverse Engineering) for short.

At present, the commonly used methods for acquiring physical three-dimensional geometric data are CMM measurement, laser line structured light scanning [6], computer scanning (CT) method, etc. At

present, domestic manufacturers use more CMMs and 3D scanners produced in the UK, Italy, Germany, Japan and other countries to obtain data information [7]. These methods all require special equipment and software packages, the price is very expensive, so that its application is subject to certain limitations.

In this paper, the 3D modeling design of gears is used as an example to introduce the system planar parts to generate 3D solid modeling method [8], which is accurate, fast, simple and inexpensive to model 3D entities. It is suitable for the development of various mechanical plane parts.

II. FUNDAMENTALS

Reverse engineering is a combination of a series of analysis methods and application techniques for digesting and absorbing advanced technologies [9]. It takes the physical objects, software (drawings, procedures, technical documents, etc.) or images (pictures, photos, etc.) of advanced products and equipment as research objects, applies modern design theory methods [10], production engineering, material science and relevant professional knowledge to carry out systematic and in-depth analysis and research, explores and masters its key technologies [11], and then Develop advanced products of the same kind [12]. Reverse engineering has a wide range of meanings, including design inversion, process inversion, management inversion, etc.

Physical reverse engineering is to analyze and study the design principle, structure, material, process assembly and packaging of the product concerned based on the product, and develop a new product which is the same or similar to the prototype [13]. Therefore, it is a process of understanding the product, reproducing the product or creatively developing the product.

Generally speaking, product reverse engineering includes several aspects such as shape inversion [14], process inversion and material inversion, etc. In the practical application in the industrial field, it mainly includes the following contents:

- (1) The design of new parts, mainly for product modification or copy design.
- (2) Reproduction of existing parts to reproduce the design intent of the original product.
- (3) Restoration of damaged or worn parts.

(4) Digital model testing, such as inspection of product deformation analysis, welding quality, etc., as well as for model comparison, reverse engineering technology provides excellent technical support for rapid design and manufacturing, and it has become one of the important and concise ways of manufacturing information transfer.

III. IMPLEMENTATION METHODS AND SECONDARY DEVELOPMENT

The design concept of the inverse CAD 3D model system is a 3D geometric data acquisition method for flat parts [15]. Taking the scanned drawing of a gear as an example, since each cross-section of a flat gear part has the same shape, using this feature, a scanner is used to obtain the cross-sectional graphics of the physical part, which is processed by some image software to generate a bitmap with only two colors. Then, we used VB.NET programming to analyze and process the image and find the coordinates of each point of the contour line. The coordinates of the points are then developed with AutoCAD 2004, and the smooth contour lines are drawn by non-uniform rational B spline curve fitting or quadruple EB spline fitting. It is also possible to refine and modify the curve fitting points by dragging them with the mouse according to the actual situation. Fitting points do not necessarily take all contour line points, according to the actual effect of graphics, a certain number of intervals to take the value of the curve drawn contour lines with Add Region method for the surface domain, and then the surface domain with Add ExtrudedSolid method, according to the thickness of the stretch into a three-dimensional model, that is, to obtain a three-dimensional solid model. Boolean operations, the outer contour of the three-dimensional entity minus all the inner contour of the three-dimensional entity, the completion of the three-dimensional model of the part inverse. Finally, according to the needs of engineers, in MDT, including ansys, almost all the analysis, modeling software packages open for finite element analysis or further modeling.

During the design process it is worth noting that not all points are selected, only which points are necessary are determined, while some other points are only up to refine the role in the process of determining the contour lines. In order to make the fit better, some points or lines with better scanning quality should be selected for the fit.

Net language in Windows 7 environment, using object-oriented design method, the architecture of the whole system is shown in Fig 1.

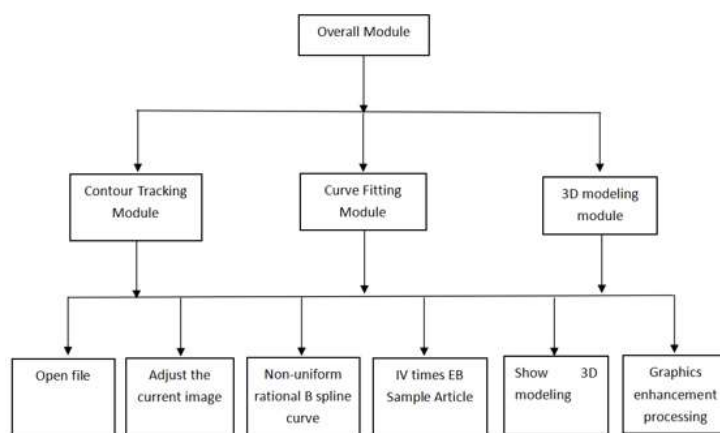


Fig 1: System architecture diagram

3.1 Tracking Profile Module

The most essential thing in reverse engineering is to trace the contour lines of a 2D bitmap. First, checking whether the image pixels are in black and white, or other two different colors, in order to speed up the recognition, the location of the starting point should preferably be chosen in the uppermost and leftmost position of the black (white) pixels in the whole screen. Second, as shown in Fig 2: set point P as the starting point of external contour recognition, the color is black, check 0 to 7 from point 0, if all are white, then black is an isolated point and stop tracking.

1	2	3
0	P	4
7	6	5

Fig 2: contour line tracing template

Assuming that P has been detected P_n, use P_n as the center pixel of the template and search P_{n+1} in the same way. If the search results in P_n = P₁ and P_{n+1} = P₂, then a closed curve has been formed and the trace of the contour line is terminated. In this case, it should be noted that the starting point of the new search must be outside the area enclosed by the obtained contour line, so as to ensure that the contour line is not the same in both searches.

3.2 Curve Fitting Module

There are many mathematical methods to deal with free curves, such as cubic parametric splines, Bezier curves, B-spline curves, non-uniform rational B-splines (NURBS), and EB-spline methods.

The following is a brief description of the quadratic EB spline: The vector equation of the quadratic EB spline is

$$P_i(t) = \sum_{j=0}^3 E_j(t)_{r_{i+j}} \quad (0 \leq t \leq 1; i = 1, 2, \dots, n-3) \quad (1)$$

Where E_j(t) is a quadratic polynomial with respect to parameter t and is called the quadratic EB spline basis function. Given the connection condition of the EB spline, the following equation can be derived.

$$P_i(t) = G_i(t) + kF_i(t) \quad (2)$$

$$(0 \leq t \leq 1; i = 1, 2, \dots, n-3)$$

Among them.

$$G_i(t) = [t^4 \quad t^3 \quad t^2 \quad t \quad 1] [A] [r_i \quad r_{i+1} \quad r_{i+2} \quad r_{i+3}]^T$$
$$F_i(t) = [t^4 \quad t^3 \quad t^2 \quad t \quad 1] [A] [r_i \quad r_{i+1} \quad r_{i+2} \quad r_{i+3}]^T$$
$$[A] = \begin{bmatrix} 1/2 & -1/2 & -1/2 & 1/2 \\ -3/2 & 5/2 & -1/2 & -1/2 \\ 3/2 & -3 & 3/2 & 0 \\ -1/2 & 0 & 1/2 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}$$
$$[B] = \begin{bmatrix} -3 & 3 & 3 & -3 \\ 8 & -12 & 0 & 4 \\ -6 & 12 & -6 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & -2 & 1 & 0 \end{bmatrix}$$

The local modification of quadratic EB spline is good, and because a parameter k with a more obvious geometric meaning is introduced in the curve equation in EB spline, it enables the designer to adjust the shape of the curve intuitively; when using quadratic EB spline for interpolation operation, the design method and calculation method are unchanged, and only the parameter k needs to be taken to zero. This is extremely useful for the preparation of calculation programs, and the calculation speed is much faster than the backcalculation when B spline interpolation curve is used.

3.3 D Modeling Module

The coordinates of the points of the contour line obtained above are fitted with four EB spline curves and non-uniform rational B spline curves, the fitting points are not necessarily taken all contour line points, and can be spaced according to the actual effect of the graph, with a certain number of interval values. The smaller the interval, the higher the accuracy, the closer to the original contour; the larger the interval, the lower the accuracy, the better the fitting effect, the smoother the curve. It can be to modify the fitted points on the curve by dragging them with the mouse according to the actual situation.

The contour drawn by the spline curve is defined as a surface domain by the Add Region method, and then the surface domain is stretched into a three-dimensional model according to the thickness by the Add Extrude Solid method, i.e., a three-dimensional solid model is obtained. Finally, the outer contour entity is

subtracted from the inner contour of all three-dimensional entities, and the three-dimensional model of the part is completed. Direct 3D view in AutoCAD allows you to observe the part from a different orientation.

To prevent unsatisfactory scanning results, i.e., graphics processed with more than two invisible colors. This can be handled by the graphics enhancement function. Transform the scanned graphic to a solid color, then refresh it, and finally display the refreshed image.

IV. APPLICATION EXAMPLES

By introducing some basic theories above, i will introduce the specific implementation process of the system and its application by citing gears as an example on top of the system development.

First, find the "gear.bmp" file in the file open mode, as shown in Fig 3.

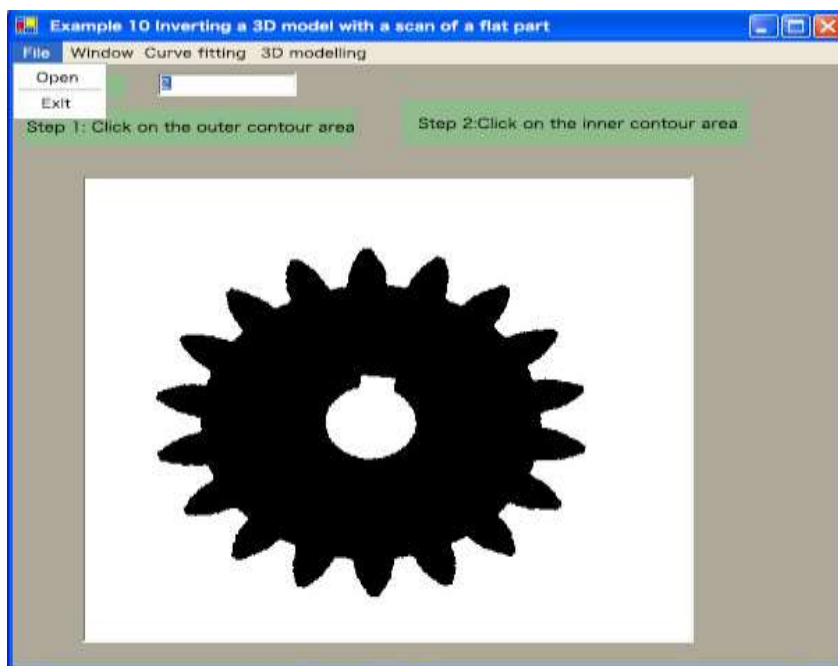


Fig 3: scanning map generation 3D model system main interface

Secondly, we can choose the way to view the image in the window. There are methods such as tiling and vertical tiling, which can make the image appear in the interface in different ways in the window.

Then, trace the contour line through the program. Following the first step of the prompt, click on a point in the outer contour area, as shown in Fig 4, and the outer contour line appears at the far left end of the screen.

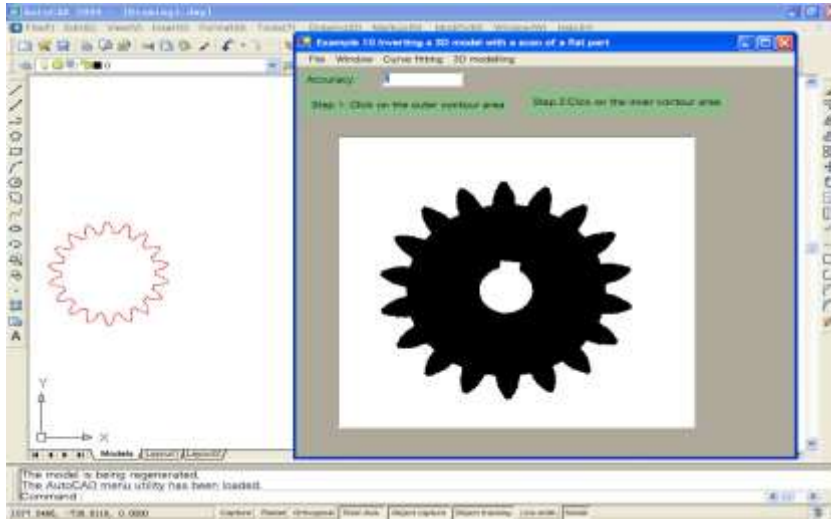


Fig 4: modeling external contour line

Then follow the second tip and click on a point in the inner contour area, and the inner contour line appears on the left side of AutoCAD as shown in Fig 5.

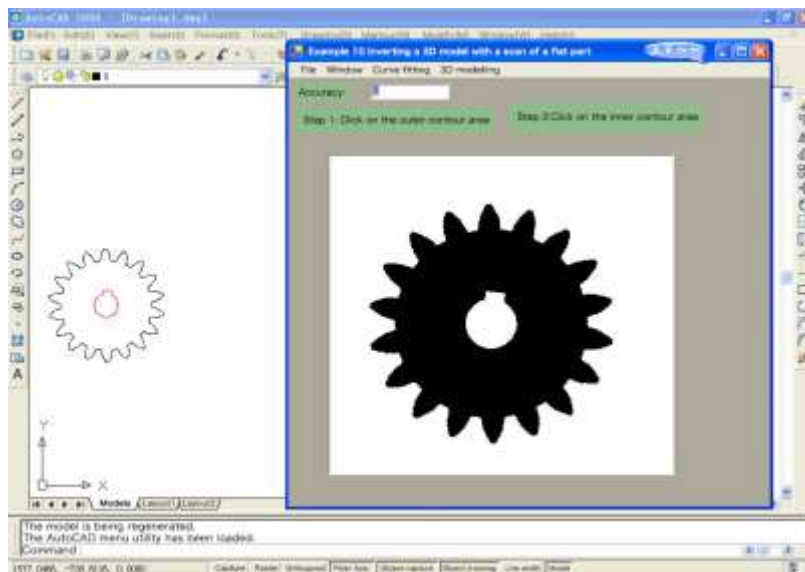


Fig 5: modeling internal contour line

Finally, by stretching and Boolean operations on the inner and outer contour lines and programming, we can realize the 3D modeling. We can click [Show 3D Modeling] in [3D Modeling] to generate a three-dimensional structure model as shown in Fig 6.

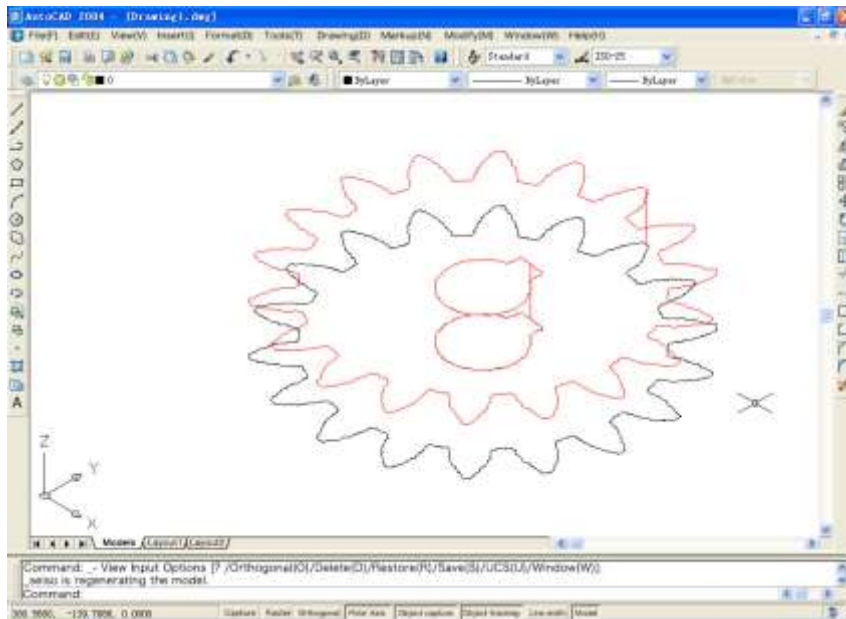


Fig 6: gear 3D modeling

At this point, the inverse inverse CAD 3D modeling system is complete. The part model can be viewed from different perspectives by body coloring in AutoCAD. As shown in Fig 7, the surface of the solid model contour obtained by inverse modeling is smooth and fluid.

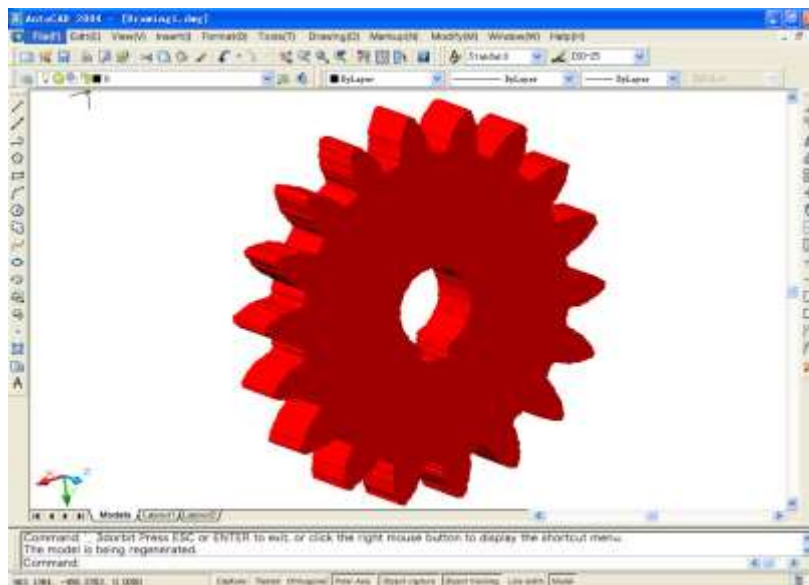


Fig 7: body coloring 3D modeling in AutoCAD

V. CONCLUSION

The development of a system for generating CAD 3D models from scanned drawings was achieved using object-oriented VB.NET programming technology and the ARX development environment support provided by AutoCAD 2004. The system is generated as a dynamic link library, compiled and linked with VB.NET, and can be used as a stand-alone module directly in the AutoCAD drawing environment or as a subsystem in a mechanical CAD application software.

REFERENCES

- [1] Zhang Jinxi (2004) VB.NET Secondary Development AutoCAD Examples in a Nutshell. Tsinghua University Press. ISBN 7-302-07605-7
- [2] Liu Zhisheng, Huang Chunying (1992) Inverse Engineering. Mechanical Industry Press
- [3] Wang Jingmei, Wang Debin, Yin Yuan (2001) Application of Reverse Engineering Technology in Mold Manufacturing. Institute of Mold Technology 01: 3-6
- [4] Sun Jiaguang (1998) Computer Graphics (3rd ed.). Tsinghua University Press. ISBN: 978-7-302-03082-9
- [5] Zhao Rujia (1995) Basic Theory and Application of CAD. Xi'an Jiaotong University Press. ISBN 7-5605-0534-1
- [6] Se-Jung Lee, Gyung-Jin Park (2014) A novel method of reverse engineering using axiomatic design. Journal of Mechanical Science and Technology 28 (2): 595-604
- [7] Feng Li, Andrew Peter Longstaff, Simon Fletcher, Alan Myers (2014) Rapid and accurate reverse engineering of geometry based on a multi-sensor system. The International Journal of Advanced Manufacturing Technology 74 (1-4): 369-382
- [8] Kunal Soni, Daniel Chen, Terence Lerch (2009) Parameterization of prismatic shapes and reconstruction of free-form shapes in reverse engineering. The International Journal of Advanced Manufacturing Technology 41 (9-10): 948-959
- [9] Guanglei Liu, Kai Chang, Zeliang Liu (2013) Reverse engineering of machine-tool settings with modified roll for spiral bevel pinions. Chinese Journal of Mechanical Engineering 26 (03): 573-584
- [10] Alexandre Durupt, Sébastien Remy, Guillaume Ducellier (2010) KBRE: A Knowledge Based Reverse Engineering for Mechanical Components. Computer-Aided Design and Applications 7 (2): 279-289
- [11] Sharma D, Sharma S, Sanu K, Saju S, Deshpande D, Kannan S(2006) Performance evaluation of a dedicated computed tomography scanner used for virtual simulation using in-house fabricated CT phantoms. Journal of Medical Physics 31(1):28
- [12] Fule Wu, Xiaojun Chen, Yanping Lin, Chengtao Wang, Xudong Wang, Guofang Shen, Jing Qin, Pheng-Ann Heng (2014) a virtual training system for maxillofacial surgery using advanced haptic feedback and immersive workbench. Int J Med Robotics Computer Assist 10 (1): 78-87
- [13] Gao Zhikai (2021) Application of reverse engineering and 3D printing technology in industrial design. Equipment management and maintenance 20: 100-102
- [14] Li Pei (2022) Innovative design of products based on 3D printing and reverse engineering. Modern Industrial Economy and Informatization 12 (01): 19-51, 54
- [15] Cao Yueying (2021) Research on the design of computerized mechanical product modeling based on reverse engineering, Mechanical Design 38(10): 151