http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (24): 8196-8200, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.8196.8200

Research on the Reverse Engineering Technology Based on Solid Feature

Li Ming and Li Quan-qing
Zhengzhou Institute of Aeronautical Industry Management, Zhengzhou, Henan 450015, China

Abstract: Reverse engineering is an important technology to realize product innovation based on prototype, the core of reverse engineering is innovation, 3D reconstruction is the bottleneck problem of reverse engineering technology. This paper puts forward a new method to realize 3D reconstruction that takes slicing data of prototype as original data, under the commercial CAD modeling software environment and briefly introduces the system developed by authors. This system reads in the slicing data of the prototype, after pretreatment and feature recognition, outputs feature data, realizes 3D reconstruction and construct the CAD solid model of prototype under the SolidWorks environment. The innovation of this system is: according to slicing data, directly construct the solid model.

Key words: 3D reconstruction, CAD solid model, function module, reverse engineering

INTRODUCTION

Knowledge economy epoch sets an even higher demand for renewing products. It is an important way to innovate and increase business's competitiveness by reverse engineering to redesign and improve existing products.

Reverse engineering is a science technology that is widely used in mechanical manufacture, modern-design-method, computer hardware, computer software and computer graphics. Reverse engineering is the important means of digestion and absorption, innovation for imported products (Liang and Lin, 1997; Abella *et al*., 1994; Liu *et al*., 1998). The most difference between reverse engineering and copy technology is that the product model constructed by reverse engineering is CAD model. After obtaining CAD model it can be modified and re-designed in order to realize the innovation purpose.

KEY TECHNOLOGY OF REVERSE ENGINEERING

Digitizing the part and constructing CAD model are the key technology of reverse engineering (Luan *et al*., 2003).

Digitizing the part refers to adopt some measuring methods and equipments to acquire the geometry coordinate of the part. In the process of the part digitizing it must solve that the measuring method, the accuracy, the number and the arrangement of collection points and the measuring process have the influence on 3D reconstruction. Now industrial CT and layer-layer slicing have become the main methods. They have be used more and more in slicing measurement. SdRe system used the measuring method of layer-layer cutting image to obtain the slicing data.

The method to construct CAD model that is commonly used in the reverse engineering technology at home and abroad is: to recognize the border to the slicing data automatically or manually; the 3D dots are grouped according to the feature single principle; to carry on surface modeling for each group dots; the last is solid modeling (Chow *et al*., 2002; Huang *et al*., 2001). That is to link up each surface to form a complete part. The surface modeling theory and algorithm are basically ripe but the research of oriented solid modeling of reverse engineering is still not reach the ideal practical level, therefore, in the aspect of constructing CAD model is looking forward to have a breakthrough as soon as possible.

FUNCTIONS OF SDRE SYSTEM

Reverse engineering system based on slicing data, short for SdRe system is the reverse engineering system software of constructing products 3D model based on slicing data which is developed by us. SdRe system includes three function modules: Slicing data processing; feature recognition: 3D reconstruction.

Slicing data processing: The data obtained after digitizing the part is the bitmap image of all slicing layers of the part prototype. Processing these slicing images have two steps: filtering out noise and extracting borders. In image filtering technology, global filtering technology requires to know the statistic model of signal or noise in

Corresponding Author: Li Ming, Zhengzhou Institute of Aeronautical Industry Management, Zhengzhou, Henan 450015, China

advance which for the slicing images is almost impossible, so SdRe system uses the local filtering technology which uses the local operators to do local treatment for the images in turn. SdRe system has a filter function library including a lot of filter functions. The user can select appropriate function for various image qualities and modify the filtering parameters, in order to get the best filtering result. Then the system extracts borders after filtering image, the image information is constructed as the ring chain that is composed of interconnected pixels. Aiming at the slicing data of object prototype in reverse engineering must be a ring of respective closed and mutually disjoint; the system has designed a effective arithmetic of extracting borders oriented reverse engineering. While extracting borders the system's parameters can be modified by man-machine conversation to eliminate useless data like air holes and chips. Moreover it can also distinguish wether the convex feature or concave feature for extracted border. The concave means the solid surface materials to be removed, such as a hole while the convex means the solid surface to possess materials, such as a cylinder. After extracting borders, the data become each closed ring composed of ordered dots which is named data ring.

Feature recognition: SdRe system uses feature model to construct CAD model, so the work of stage two is the feature recognition. Data ring after feature recognition is constructed the data that expresses object prototype feature, that is feature ring. This is the core model of the system.

3D Solid reconstruction: SdRe system selects the commercial CAD modeling software, such as SolidWorks, as system support software of 3D modeling. SolidWorks is 3D modeling software oriented computer. Its function is powerful, the cost is cheap and it easily realizes the interfaces with the programming language and other commonly used CAD software (Wen, 2004). At the same time, on the support of commercial CAD modeling software, the 3D solid model can be modified it can output the part drawings and assembly drawings, as well as the files to be read by other CAD softwares that are commonly used it still can output the STL files for the rapid prototyping (Schreve *et al*., 2006). Using SolidWorks as support software, can save the research work to realize basic function, to focus on the key technology of reverse engineering. Solidworks provides the soft interface with programming language. Using this interface, SdRe system develops the interface module. Under SolidWorks environment, to run this module, input the feature data produced by feature recognition module, the CAD model of the product can be reconstructed.

FEATURE RECOGNITION MODULE

The feature recognition module is the core of SdRe system. It completes feature recognition function, so as to realize 3D solid reappear. SdRe system read in the data of data ring, output the feature ring data for SolidWorks modeling.

The feature defined in this paper is modeling feature which means the solid and surface that can be constructed one time using single modeling method under CAD modeling software environment. The essence of feature recognition is to classify and deal with the data. The data composing the same feature combines in together and recognize the type of the feature. The closed contour data in the slicing section is called data ring, the data composing the same solid is called solid ring. This group of data after recognizing feature type of the solid is called feature ring.

Feature types: SdRe system to recognize the feature from the three levels of line, surface and solid, the feature types are shown in Fig. 1.

From the standpoint of feature body, the features that are constructed by SdRe system have two types: extruding body and extruding body of layer change. The extruding body is the feature that the shape and size of cross section do not change; it is the equal cross section body, such as the cylinder, prism. The extruding body of layer change is the body with variable cross-section, the size and shape of its cross-section are changed. The feature body of containing free surface is one of the extruding body of layer change. From the standpoint of feature plane, SdRe system can construct plane, cylinder surface, cone surface and free-form surface, each surface can be outside surface, also can be inner surface.

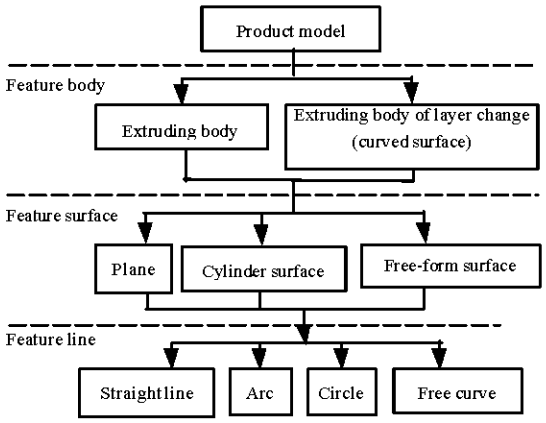

Fig. 1: Feature types

From the standpoint of feature line, SdRe system can construct straight line, arc, circle and free curve, as well as the polygon by their combination.

SdRe system recognizes the feature body and feature line with explicit recognition form and the feature surface with implicit recognition form, for the feature surface recognition is included in the recognition of the feature body and feature line.

Feature recognition manners: As mentioned above, the data ring actually is the data that a certain feature of object prototype is reflected in a certain cross section. Some data ring that expresses the same feature surface of the object prototype, distributes in different cross section are congregated, that is formed a new data chain, named solid ring. Solid ring is actually the data ring collection that expresses the feature surface of the object prototype. The solid ring after feature recognition is feature ring.

From the standpoint of automation, feature recognition has two manners: Interactive recognition and automatic recognition (Li *et al*., 2003). Automatic mode can recognize the two types of feature line of straight line and free curve and all feature body; interactive mode can recognize all feature line and feature body. From the standpoint of checking the recognition results, in the interactive recognition there are two manners of relatively recognition and absolute recognition. For relative recognition, the system to the results of interactive recognition carries on fitting operations by means of least squares, in order to check the recognition correctness, if the error exceeds the specified threshold value (the value may be modified by user), then give warning information and the user decides to recognize again or ignore the system warning. Using absolutely identify way, directly accept the artificial recognition results, no longer inspection. From the standpoint of working process, there are direct and indirect recognition. When carry on indirect recognition, the first is to recognize feature line and then to recognize feature body it is mainly used for recognizing the complex feature body. Direct recognition is to recognize the feature body directly, is mainly used for recognizing the simple feature body. If need to recognize the complex feature body, the system will guide users to recognize feature line.

SUBFUCTION MODULES OF SDRE SYSTEM

In order to carry on the feature recognition work efficiently and conveniently it has carried on the function decomposition and the module partition to the system and developed the corresponding subfunction modules. The structure of subfunction modules system is shown in Fig. 2. Its main function modules are briefly described as follows:

Constructing solid ring: The process to construct the solid ring is the matching process of the data ring. That is according to certain principles and algorithms, all data rings of the same feature surface of the object prototype will be combined together to construct a solid ring. In order to calculate simply and improve efficiency, this software uses the data ring to match directly, that is using dot image of data ring to match, rather than the dot image of data ring is vectorized into the geometry image at first, then to match them again. In this way it has spared the vectorization work of thousands of data ring dots in hundreds of images, greatly improving the processing speed.

Using dot image to match directly, at present there is no literature to introduce the algorithm. The data ring matching method that is constructed by our system, from the three aspects of shape, location and size of dot image to judge the matching relation of dot image. Completely matching in certain error range, compose the extruding body; incompletely matching, compose the layer changed extruding body; can't match at all, that illustrates the dot images are belong to different feature surface separately. The modeling coefficient that expresses the matching relations can be adjusted through modifying the system variables by the system operator. Modeling coefficient size has determined the feature modeling precision and the feature number.

Images display: In the different stages of the system running, all kinds of images will be displayed in the screen timely for operator to understand the situation and control the operation. After the solid ring is constructed, the operator can choose solid ring to display wholly, partly or single ring displays. The operator can be used the mouse to choose some one solid ring to edit or model. If need to recognize feature line it will display the plane figure of the data ring, the operator can drag and move the mouse with the method of open Windows to choice the dot group.

Solid ring editing: The construction of solid ring is completed automatically by system according to the modeling coefficients. The system operator can use the solid ring editing functions which is provided by the system to edit the solid ring, to carry on the operations of deleting, separating and combining for the solid ring. Deleting solid ring, that is to modify the data of the original data ring in order to eliminate futility data like air

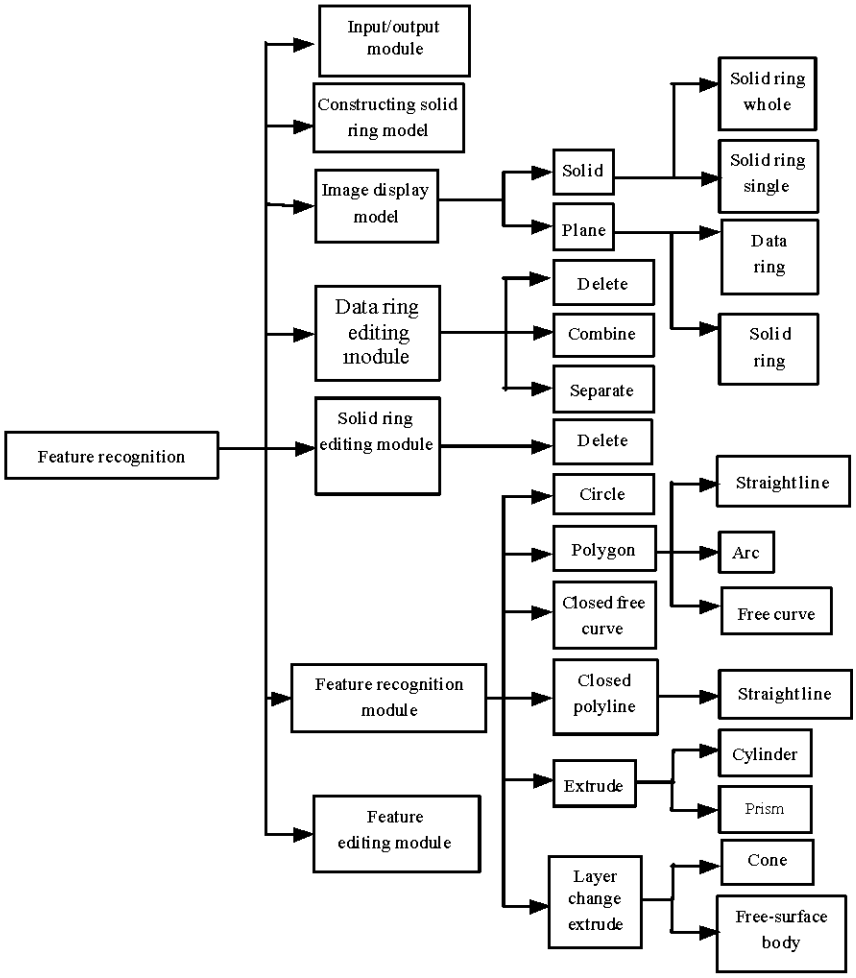

Fig. 2: Subfunction modules of feature recognition

holes and chips. Separating is from a solid ring (compound solid ring) to be separated another solid ring, one ring is became two rings. Combining is that two solid rings will be combined into one ring. When combining, SdRe system will be according to the shape of the space position and the plane position of the two rings to judge whether the solid rings can be combined, if the system think them unfavorable combine, will give warning, please the operator confirm or give up; if the system think them cannot combine it will give error messages and refuse to combine.

Data ring editing: The deleting operation for the data of solid ring can be done, that is to delete the current data ring (slicing) that is composed of the solid ring, in order to eliminate redundant data.

Feature recognition: After solid ring is constructed, in order to construct the feature ring, the geometric recognition to the data composed of solid ring need be completed. The system uses the above various methods to recognize the feature line and feature body.

Feature ring editing: Feature ring that has constructed already is displayed in the form of a tree, in order to do the editing work for it when necessary. This editing work is mainly to meet the requirements of SolidWorks. The editing work includes two contents, one is to adjust the modeling order of the feature ring, another is to adjust the corresponding relation of data point in surface body.

CONCLUSION

3D reconstruction method that puts forward in this paper is to directly construct the CAD solid model of the prototype based on slicing data of the prototype and under the commercial CAD modeling software environment, this is a new method. Previously, the reverse

engineering method generally is to construct the local surface model of the prototype first, then to match and joint the surfaces and get the whole surface model. In the process of the surface matching and jointing it is very complicated to deal with the problems of surface tearing and overlap. The method that research in this paper avoids these problems. The method is to realize 3D reconstruction in commercial CAD software environment, so it will save much time to develop the additional modeling software or modules. In addition, in the mechanical manufacture field, the most of parts are composed of the regular surfaces, so this method has unique advantages in the reverse engineering of mechanical manufacture field.

REFERENCES

Abella, R.J., J.M. Daschbach and R.J. Mcnichols, 1994. Reverse engineering industrial application. Comput. Ind. Eng., 26: 381-385.

Chow, J., T. Xu, S.M. Lee and K. Kengskool, 2002. Development of an integrated laser-based reverse engineering and machining system. Int. J. Adv. Manuf. Technol., 19: 186-191.

Huang, X.P., X.M. Du and Y.L. Xiong, 2001. Modelling technique in reverse engineering. China Mech. Eng., 12: 539-542.

Li, D.Z., M.J. Wang and Y. Liu, 2003. Research on interacted-modeling method for reverse engineering. China Mech. Eng., 14: 1677-1680.

Liang, C.C. and G.C. Lin, 1997. An integrated reverse engineering approach to reconstructing free-form surfaces. Comput. Integr. Manuf. Syst., 10: 49-60.

Liu, Y., J.Q. Hang and Y.Q. Wan, 1998. Reverse engineering and modern design. J. Mach. Des., 12: 1-4.

Luan, Y.G., H.F. Li and B.T. Tang, 2003. Reverse engineering and its technologies. J. Shan Dong Univ. (Eng. Sci.), 33: 114-118.

Schreve, K., D. Dimitrov, C.L. Goussard and A.H. Basson, 2006. Interactive feature modeling for reverse engineering. J. Comput. Inform. Sci. Eng., 6: 422-424.

Wen, X.H., 2004. Reverse engineering technique of complex surface product based prototype. Mech. Electr. Inform., 8: 35-37.