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Review Article

Discussion on Reverse Design of Components with Complex Curved Surface and Computer Numerical Control Machining

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Abstract: With the continuous development and advancement of science and technology, the work of tool path planning has received extensive attention. Among them, curved surface generation and data processing are the focus of management and design, which necessitate the full application of reverse design of complex curved surface components to complete numerical control processing, effective optimization and upgrading, integration the tasks of point cloud data collection, and point cloud data processing to ensure that the corresponding computer numerical control machining model can exert its actual value. This paper briefly analyzes the basic principles of curved surface reconstruction as well as discusses the reverse design of complex curved components and the experimental processes and results that involved computer numerical control machining, which serves the purpose as reference only.

Keywords: *complex curved surface; component; reverse design; computer numerical control machining*

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0 Introduction

Due to the exceptional complexity of structural profile, Geomagic Studio software is needed to solve difficulties in curved surface generation, data processing, and many other problems. It is necessary to integrate the model quality inspection process and give full play to the numerical control automation programming processing factors and quality evaluation mechanism to ensure that the forward modeling and rapid fitting can be adopted to effectively improve the flexibility and reliability of the robot wrist application.

1 The analysis of the basic principle of curved surface reconstruction

The reconstruction process of the structure designed based on the parts' 3D surface model runs through the entire reverse design and has significant meaning and value. It is mainly supported by judgment of data interpolation managing process and the fitting method to effectively complete the scanning process. Subsequently, the point cloud data complete the simulation structure that infinitely approximated components' prototype, and the 3D-digitized curved surface model can be effectively presented by the conformation of the components, which integrates the basic level of management task and needs to establish a complete innovative and optimized structure[1].

It should be noted that the more common curved surface reconstruction is mainly divided into two types, one is the Bézier surface, which is the basic triangular surface processing and construction mechanism[2]. The other is the non-uniform rational basis spline curved surface foundation, which can effectively form a four-sided threshold processing construction mechanism. Compared with the latter, the adaptability and flexibility of the triangular patch fitting processing mechanism are more prominent, and it can effectively construct a more complex curved surface structure and operating system. First, one type of curved surface reconstruction is the Bézier curved line and curved surface structure. This kind of curved line structure has almost approached the design of the actual curved line structure and curved

surface structure. In the practical application projects, it mainly uses the arc management of multiple points of spline curves and effectively approximates the actual curved surface analysis system[3]. For example, the more widely used is the Cubic Bézier curve, to effectively approximate the curve and the graph, as shown in Figure 1.

It can be seen from the curve that four vector points Q1/Q2/Q3/Q4 are the key points in the whole system, and different vector lines form a more critical tangent relationship, which can effectively utilize $P(t)=\sum_{i=0}^{n} B_{i,n}(t)Q_i$, where t ranges from between 0 and 1, n represents the number of variables, and t represents the value of the variable. In addition, it is also necessary to combine with the matrix and apply comparison process. Precisely due to its ability to utilize the rationality of the cubic Bézier curved surface to replace the high-order curved line, it is, therefore, frequently applied in industrial design and can effectively realize the processing of adjacent line segments, despite the change can be achieved but the control cannot be completed[4].

Second, the Bézier curved surface is mainly a bicubic Bézier surface structure, as shown in Figure 2.

Combined with the Bézier mesh curved surface, it is known that it is a curved surface structure composed of polygons, in which the control endpoints have to follow along both the directions of v and u to form the basic mesh system orderly. This kind of construction method is relatively simple. After the laser scanning device acquires the point cloud data, the data integration process can be effectively realized by combining the fitting process. Most importantly, after analyzing the Bézier curved surface, it can effectively implement software applications[5].

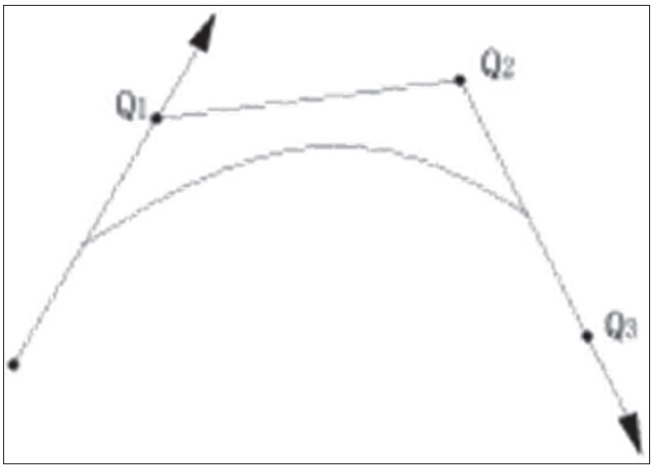

Figure 1. Bézier curved live

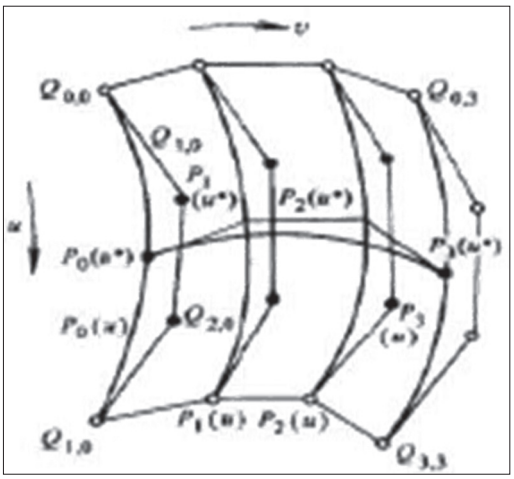

Figure 2. Bézier curved surface

2 The reverse design of complex curved surface components and the experimental process of computer numerical control machining

In the process of verifying the theoretical analysis process and the correctness of the tool path planning, the three-dimensional model is exported in STL format, and input to the rapid prototyping machine to print out the three-dimensional model of the bone. It should be noted that the robot is mainly used in heavy-duty workplaces such as machining and assembly. Therefore, the requirements for the wrist joint are relatively high and the relevant technicians must carry out the computer numerical control processing on the joint components to rationally complement the management effect[6]. The most important thing is that, during the process of numerical machining, it is necessary to systematically judge the structure of the components, to evaluate the different modeling structures, and to analyze the process parameters by means of the five-axis machining center cutting test, rationally integrate three-coordinate processing mechanism to ensure the operational integrity of the component testing experimental project, and to effectively improve the rationality of the overall processing work.

2.1 Completion of computer numerical control automatic programming

After analyzing the structural profile from the component aspect, it was found that it is composed of some comparatively complex curved structures. To process and optimize the program, it is necessary

to integrate the arc transition process of the curved joint position and to completely connect with other components to ensure the formation of good connection effect between the screw through hole and the threaded hole Figure 3[7].

In the process of complex curved surface connection processing, the description of the components' size data is more critical because the ordinary machining equipment cannot be used for processing. Therefore, this study used the automatic programming software PowerMill complemented with four-axis machining center to process and control. After applying PowerMill, the machining strategy is mainly realized by means of automatic programming module, which can effectively improve the efficiency of roughing operation as well as effectually identify some complicated tool paths using different cutting modes and to guarantee the finishing processing and high-precision machining strategies and maintain the rationality of the management and control workflow[8]. In addition, after applying the PowerMill software, the finishing processing effect can be maintained and the driving mode and the cutting mode can also be integrated to ensure the maintenance of the computer numerical control programming processing of the wrist joint components. The specific parameters are: (1) The roughing process, the milling cutter is a Φ16 flat-bottomed knives, using the machining strategy of model area clearance to complete the specific operation, with the cutting step of 10 mm, the chemical reserve of 0.5 mm, and the spindle speed of 3500 r/min. (2) The plane finishing process, the milling cutter is a Φ 12 flat-bottomed knife, using machining strategy of the flat surface treatment to complete the specific operation, with the cutting step of 9.6 mm, the chemical balance of 0, and the spindle speed of 5000 r/min. (3) Sidewall finishing process, the milling cutter is a Φ 12 flat-bottomed knife, using the machining strategy of contour finishing to complete the specific operation, with the cutting step of 5 mm, the chemical balance of 0, and the spindle speed of 5000 r/min. (4) Drilling of the center hole process, the milling cutter is a Φ 3 center drill, using the drilling machining strategy to complete the specific operation, with the cutting step of 3 mm, the chemical balance of 0, and the spindle speed of 1000 r/min. On this basis, the relevant personnel should complete the specific operation process according to the actual situation and specific operational parameters to ensure the integrity of the computer numerical control machining process[9].

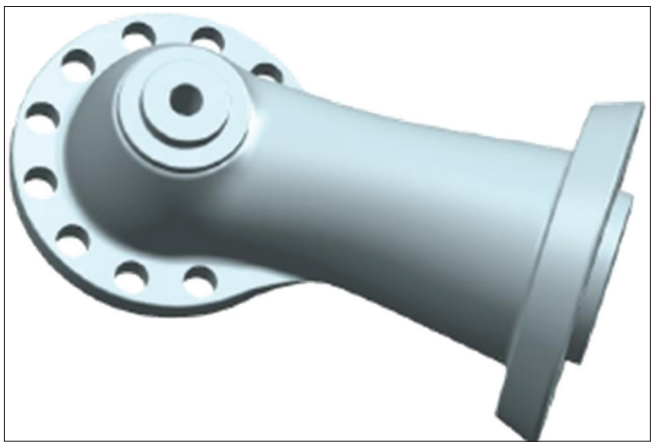

Figure 3. Schematic diagram of component connection

2.2 Completion of the main body curved surface programming machining

To ensure the rationality of the surface programming process, relevant personnel should actively establish a robust and complete processing control mechanism, improve the application efficiency of programming machining, and integrate the workpiece coordinate system and other related parameters to ensure the rationality of the analysis structure.

First, workpiece coordinate system of the wrist joint components must be selected to write and compose three coordinate axes and use the corresponding parameter relationship to determine the position relationship between the tool and the machine origin and to effectively combine the specific data of the tool to ensure data input and scientific quality between the computer numerical control milling machine and panel parameters; most importantly, the tool path of the workpiece machining process must also be analyzed during the formal machining operation.

Second, it is necessary to carry out roughing control on the main body surface and rationally remove a large amount of material of the blank and effectively ensure that the processed material can be closely approximated to the components. It is worth mentioning that, after semifinishing and finishing processing, it is necessary to leave a more uniform residual material, thereby improving the rationality of the roughing process and integrating the operating efficiency. At present, 3D milling strategy is commonly used, and along with the establishment of the corresponding model, it can rationally eliminate the surrounding cutting pass processing and parallel cutting processing, thus achieving rough machining and effectively protecting the tool[10].

Third, it is necessary to carry out secondary roughing on the main body surface, mainly to further process the basis mentioned above and to ensure that the reopening process can be completed. Besides, depending on the relevant clearing instructions of the model area, the processing can be completed in combination with the reference tool path and the unfinished residual material at the concave fillet can be scientifically processed.

3 The reverse design of complex curved surface components and numerical control machining experiment results

After conducting reverse design and numerical control machining on complex curved components, the next most intuitive step was to determine the optimization parameters. To integrate the machining strategy, it is necessary to carry out the finishing control of the rotating surface. Besides, to verify the feasibility of the numerical control program and to establish the milling mechanics model, the limited element analysis software ANSYS was used to carry out the deformation analysis and the relationship curve between machining process parameters and the milling deformation was obtained.

Based on the guaranteed tolerance, the milling process parameters were set and optimized, and the straight line fitting approximation curve method was used to conduct comprehensive process, which can improve the effect of small and medium straight line approximation process during the machining process and make perfect machining process effect. It was the measurement of the experimental structure by means of different steps.

Besides, among the factors affecting the whole system and numerical control processing results, the machining accuracy, the surface quality of the processed components, and the length of the processing time are more critical, and the rational optimization of the cutting experiment should also be managed with the above-mentioned points[11].

In addition, the machining parts of the structural profile components and the curved surface of the tool used in the machining should be combined with the automatic programming software to set the corresponding lateral step to ensure that the finishing amount can generate effect on the surface quality of the main body, combined with the corresponding regulations and selection standard to control the blank structure, and the corresponding reference system can be used to determine the blanking parameters. In this study, the 8-mm aluminum special alloy ball-end knife was used in the test on curved surface processing of the wrist joint components, which can effectively improve the precision of curved surface component design.

On the other hand, the cutting test processing and control were performed on the lateral step distance, especially on the surface roughness and the machining accuracy of the main body surface. It was found that the rationality supported by data collection by means of three-coordinate parameters can be used to determine the aspects of feed direction and line direction. Based on this, the finished products using computer numerical control machining complemented with the use of scanner are more in line with requirements of the factory application than the model processing products made with ordinary measuring tools[12].

4 Conclusion

All in all, after the reverse design and numerical control machining of complex curved components, it not only can improve the rationality and scientificity of the machining process but also improve the integrity of the operation process to a certain extent and ensure that the corresponding control process meets the scientific design requirements. To a certain extent, the advantages of new technologies will be brought into play to ensure that the precision of parts and components will essentially meet the actual needs, laying the foundation for the sustainable development of industrial robot projects.

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