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Construction of Automatic Bridge System for Vehicle Body Target Parts and Parts Based on UG Secondary Development

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Abstract: In the design of existing car body parts, some structures are primarily designed based on mechanical and material properties, resulting in similar but not identical structures. This leads to repetitive design for each project, consuming a lot of time and reducing efficiency. Leveraging the UG11 software platform, combined with NX Open and UFun secondary development technologies, and using Microsoft Visual Studio 2017 and C++ programming language, an automation bridging system for car body target parts and components was developed. The system realizes automatic bridging by selecting auxiliary surface, Angle size of vector ray, relationship between line segment and surface, automatic selection of bridge surface, offset surface, extension and pruning, merging and so on. The system is integrated as a UG plug-in to simplify installation and bring substantial efficiency gains in body part design and modeling.

1. Introduction

Body parts play a key role in enhancing the driving experience and optimizing the quality of the vehicle, and their functions and decorations work together to give users an intuitive feeling. Nowadays, the automobile industry generally adopts computeraided technology for product design and manufacture, which shortens the development cycle and greatly improves the product quality[1]. However, at present, there are some problems in the modeling of body parts using CAD 3D software. For example, the structure of existing parts is relatively mature, the structure is similar but not exactly the same, and each project needs to be repeatedly designed, which consumes a long time and has low efficiency. In vehicle manufacturing, the problems existing in the structural design of body parts will bring a huge workload and a long development cycle to the body research and development department.

NX software is an interactive CAD/CAE/CAM system with high-performance design and drawing functions that provide high performance and flexibility for design and manufacturing. It enables the construction of various complex products and models[2]. The UG software is equipped with interfaces for data exchange and geometry operations for external programs, including the UG/Open API (also known as the UFun interface, or User Function) and NX Open. Apis are seen as software development tools whose function is to facilitate effective integration between different applications by providing code in programming languages. Multidisciplinary interaction has become routine as interface methods and codes have been developed which allow the seamless interchange of data between platforms and disciplines. These methods and software platforms have the capacity to generate the information required to develop optimal engineering solutions[3]. This paper realizes the system function development through UG platform and its secondary development tools.

Because the design of body parts structure is relatively fixed, repetitive and low efficiency, the automatic design of body parts bridge function is feasible and urgent. Based on UG platform, combined with secondary development technology and according to the experience and needs of enterprise designers, this paper uses C++ programming language to complete the algorithm design under NX Open and UFun architecture, develops the automatic bridge function system of body target parts and parts, and makes a plug-in integrated on UG. The rapid automatic design and modeling of body parts is realized, which brings substantial efficiency improvement.

2. Literature review

Improving the design efficiency of automobile parts has become a key research direction in the field of automobile manufacturing, and many scholars have achieved remarkable results in this field. Kim et al.[4] achieved rapid design optimization of automotive steering knuckle components by combining multi-body dynamics simulation, finite element analysis and topology optimization methods. Anselma et al.[5] propose a rapid design approach that, through automated modeling and evaluation algorithms, enables the generation and testing of a large number of hybrid electric vehicle transmission designs in a short period of time.

With the maturity of UG secondary development technology, many scholars have realized efficient design in the automotive field through UG secondary development tools. In combination with UG secondary development, Fang Xifeng et al.[6] proposed a modular variant design method for automobile inspection tools based on template, which analyzed the similarity of product digital and modular features and automatically assigned structural component parameters. Wang Jianjun and Chen Dandan[7] proposed a method of building body glue data object based on Tecnomatix system and NX secondary development, which realized the full digital development and verification of body glue process. Li and Liang[2] proposed an intelligent design method for cutting edge blocks of automotive coverings based on parameters and sketches, and integrated it into NX software to develop an intelligent design system for cutting edge blocks. Kong et al.[8] proposed an intelligent system capable of automatically identifying and optimizing the stamping process flow and integrated it into NX software to develop an automatic typesetting analysis system, thereby improving the efficiency of automotive panel design.

UG secondary development technology is not only used in the automotive field, but also in other fields to carry out a certain degree of corresponding research. Zhou Huilan et al.[9] realized the rapid design and modification of hot runner nozzle through UG/Open secondary development tool combined with VS 2010. Tran et al.[10] proposed a method to automatically generate robotic welding programs from CAD, combined with available CAD API functions, and finally implemented this method by using Siemens NX and Python robotics toolbox.

3. Approach

3.1. UG secondary development

3.1.1. Secondary development brief

This project is developed on the UG11 platform, using C++ for key functions and VS2017 for compatibility with UG11, resulting in a 64-bit executable file. UG provides a range of interfaces and tools for users in different fields to integrate and interact with functional modules by writing code. The following is an introduction to the functions of some common tools for secondary development [11].

(1) UG/Open UIStyler: A dialog box design module with various controls for layout, interaction, and data input. Users can create custom dialog boxes and interact with them using languages like C#, C++, Java, or C via the UFun interface.

(2) MenuScript: A module for creating custom menus in UG using a text-based scripting language. It allows users to integrate external programs into the UG interface and organize menus hierarchically, with definitions saved in a .men text file.

(3) UG/Open BlockUI: An advanced dialog box design module offering improved controls and a "block" stack interface for handling large datasets and complex geometry. It supports code generation for C#, C/C++, Python, VB, and other languages.

(4) UG/Open API (UFun interface): This is the core interface for geometry operations and data exchange in UG, consisting of dynamic (.dll) and static (.lib) library files. The UG/Open API function library contains a set of functions for secondary development by users[9], it offers around 2000 functions for secondary development, allowing users to perform modeling, assembly, and geometric analysis using languages like C#, Java, and C/C++.

(5) NXOpen is the new development interface in UG, replacing UFun for geometry functions. Using the NXOpen API also allowed for the seamless transfer of information between the different systems, as client-server relationships could be deployed[10]. It supports more programming languages and offers enhanced functionality. For secondary development, both UFun and NXOpen can be used together to provide more comprehensive geometric support in this project.

3.1.2. Secondary development process

In the design of the automatic bridge function system between object and part of the body. The main call tool set of user interface generator UG/Open Block UI Styler, menu scripting language MenuScript, application programming interface UG/Open API, NXOpen C++ and other tools for development. The clear development flow is shown in Fig.1.

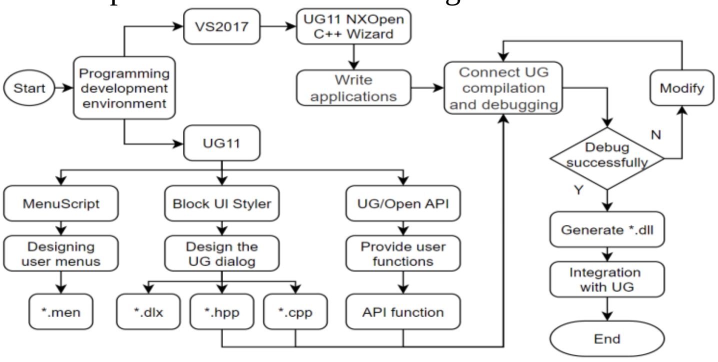


Figure 1: UG secondary development flow diagram

3.2. Part bridging

3.2.1. Overall scheme

In the process of modeling body parts, the body shape surface is mainly designed according to the design idea of the vehicle type and the engineer, so there is a certain degree of difference, and it is not easy to realize automatic design. After completing the steps of thickening the body shape surface, the next step of structural modeling needs to be carried out on the thickened body. In the existing body parts, the structure of this part is mainly designed according to the design rules such as mechanical properties and material properties, so there are similar parts, and the repeated modeling of this part will greatly affect the development progress of the automobile project. Since the body parts are integrated structures and cannot be joined by the assembly function of 3D software, similar structures are considered to be joined by generating smooth surfaces.

According to the modeling rules and basic model provided by the technical side, the automatic bridging process of the body target parts and parts is sorted out, as shown in Fig.2. Select the correct bridge target, assist in automatic or manual selection of all bridge surfaces on the bridge part, offset them, each bridge surface is separately extended and trimmed, and finally merge the target and part.

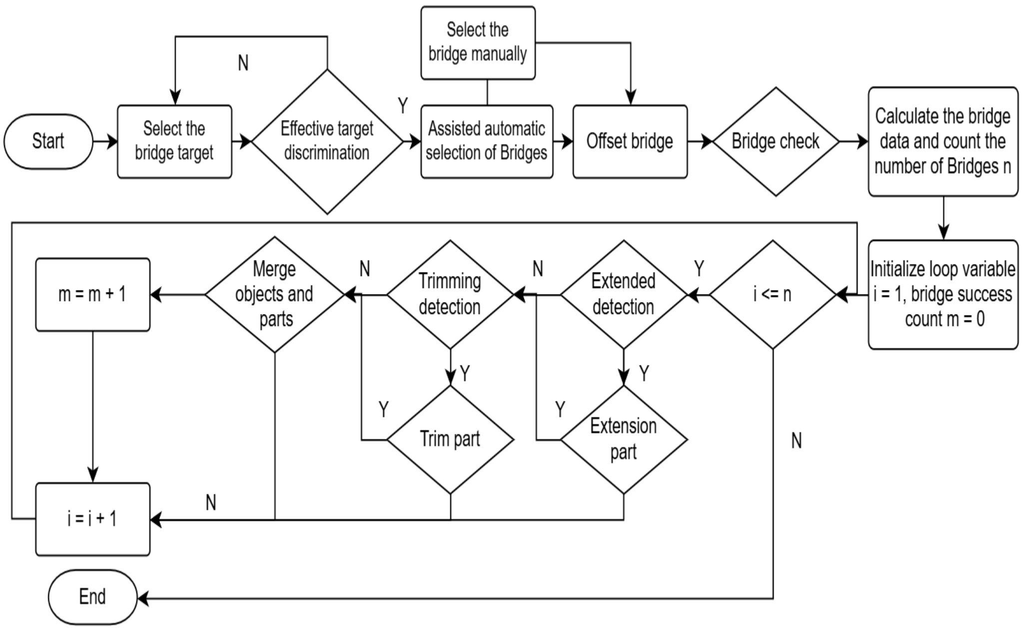


Figure 2: Automatic bridge flow chart of body target parts and parts

3.2.2. Auxiliary selection bridge surface

This paper introduces the realization method of auxiliary selection of bridge surface in part bridging processing. Fig.3 is the model demonstration diagram with explanation. The bridge part shown consists of thirteen surfaces, of which eleven surfaces A, B, C, D, E, etc. The prerequisite for the selection of the bridging surface is that the user needs to manually select the auxiliary surface first, and the selection of the auxiliary surface is generally divided into two types: the first is to select the A side convenient for the user far from the bridging area; the second is to select the C side difficult for the user near the bridging area. The vector rays of the two surfaces show that the rays of the A side point away from the bridging target. C scalar rays point in the direction of the bridge target.

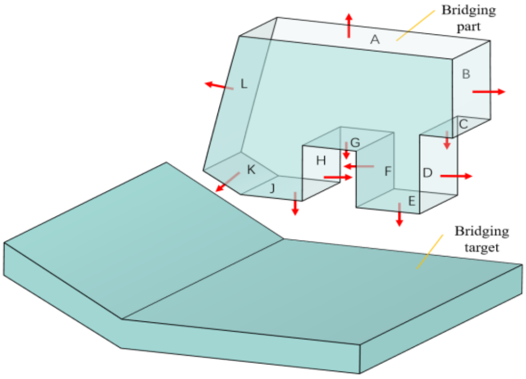
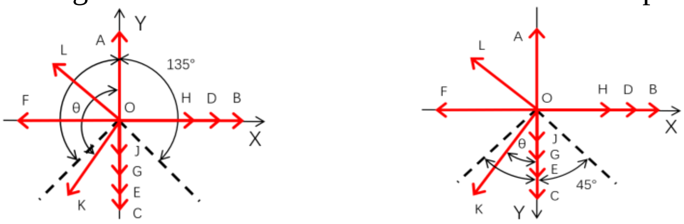


Figure 3: Auxiliary automatic selection bridge model demonstration diagram

The first step in selecting the bridge surface is to compare and distinguish the Angle between the auxiliary surface and the vector rays derived from the surface.

(1) Auxiliary surface select Surface A: The program extracts the vector rays of other ten surfaces to form an Angle with the vector rays of surface A for comparison. As shown in Fig.4, O is set as the origin, the vector ray direction of surface A is taken as the coordinate Y-axis, and its vertical direction is taken as the coordinate X-axis, and the vector rays of the remaining ten surfaces are paired with the vector rays that are drawn from the origin O in the direction away from the corresponding surface. The program is set when the Angle between the vector rays of a surface and the forward vector rays of the coordinate Y-axis is within 135°~ 180°(error ±0.001°), then the surface is judged to be a bridge surface candidate and included in the A1 parameter knowledge database. In the comparison chart, OA, OB, OD, OF, OH and OL are not in the prescribed range of included angles, so the corresponding surfaces are excluded, while OC, OG, OE, OJ and OK are in the prescribed range of included angles, so these five surfaces are included in the A1 parameter knowledge database.

(2) Auxiliary surface select C surface: Similarly, when the Angle between a vector ray on a surface and a positive vector ray on the coordinate Y-axis is within 0°~ 45°(error ±0.001°), the surface is judged to be a bridge surface candidate and included in the C1 parameter knowledge base.



(a) A surface as auxiliary surface (b) C surface as auxiliary surface

Figure 4: Vector ray Angle contrast discriminant diagram

The second step in selecting the bridge surface is to compare and judge the relationship between the line segment farthest from the auxiliary surface and the surface. The model diagram is shown in Fig.5.

(1) Auxiliary surface select Surface A: Since the vector ray direction of surface A points away from the bridge target, the line segment on the bridge part that is farthest from surface A d_1 (that is, the ray direction of OA vector is the lowest bridge part on the Y axis) is selected. The selected line segment includes four line segments a, b, c and d. Surfaces that are adjacent, tangent, etc., to these four segments are judged to be bridging surfaces. The surfaces involved in relation judgment are extracted from the A1 parameter knowledge base, including five surfaces C, E, G, J and K, among which three surfaces E, J and K meet the relation conditions, so these three surfaces are included in

the A2 parameter knowledge base as bridging surfaces. Bridges can also be manually selected later and included in the parameter knowledge base.

(2) Auxiliary surface select C surface: Similar to the above, the line segment on the bridge part that is the farthest distance d_2 from surface C (i.e. the ray direction of the OC vector as the highest point of the bridge part on the Y axis) is selected and the selected bridge surface is included in the C2 parameter knowledge base.

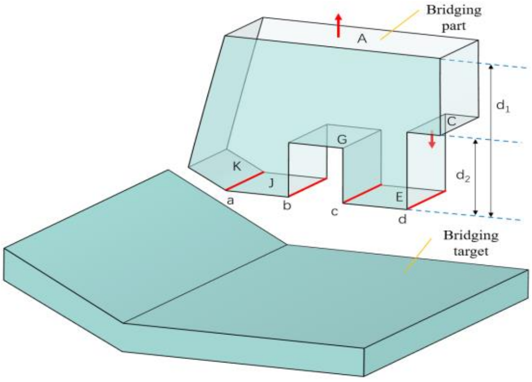


Figure 5: Diagram of the line segment at the farthest distance from the auxiliary surface

3.2.3. Bridge surface offset and inspection

The following describes the implementation of the bridge surface bias and check.

(1) First, the bridge surface is extracted from the A2 or C2 parameter knowledge base, and then the bridge part projects rays vertically from the bridge surface to the bridge target and onto the surface of the bridge target. Then, the projection distance is measured and compared, and the maximum projection distance d_3 is judged and selected as the bias distance of the bias surface to offset the bridge surface, as shown in Fig.6.

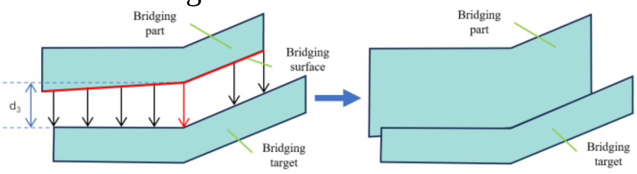


Figure 6: Bridge surface bias diagram

(2) Bridge surface inspection includes two tests: extension detection and pruning detection. Extension detection is to detect whether the bridging part and the bridging target meet the extension condition, and the extension condition is to detect whether there is no interference (two surfaces intersect or overlap) between the bridging part and the bridging target. If the extension conditions are met, that is, the extension detection is successful, then the sheet body is extracted from the surface of the bridge target and the set length L_1 is extended in the direction where no interference bias surface exists, as shown in Fig. 7(a). Pruning detection is to detect whether there are two interference surfaces after the bridging part is biased to the bridging target. For example, the interference surface in Fig. 7(b) includes the surface of the sheet and the upper surface of the bridging target, and the interference surface in Fig.7(c) includes the upper surface and the lower surface of the bridging target. If the detection is successful, the farthest surface in the bias direction of the bridge part is selected for trimming. The trimming part is the bridging entity with the surface facing the bias direction, and then the bridging part and the bridging target can be directly merged. The model trimmed according to the surface of the slice hides the extracted slice.

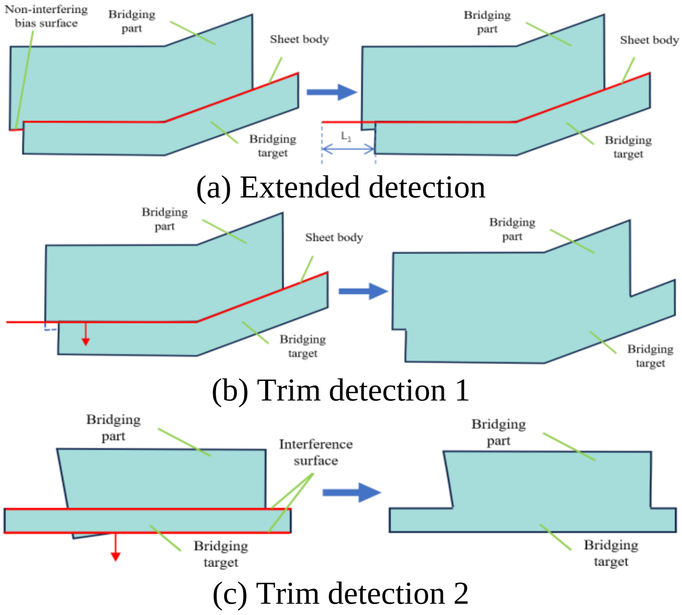


Figure 7: Bridge surface inspection diagram

3.3. Part bridging system workflow

The workflow of the whole part bridging system is as follows: First, import the thickened body of the complex modeling surface of the body as the bridge target, then select the import bridge part, select the part bridging dialog box, assist in selecting the bridge part bridging surface, choose whether to hide the bridge target, if you choose to hide, you can check and manually select the bridge surface, and then display the bridge target after completion, and finally bridge processing can be carried out. The specific work flow is shown in Fig.8.

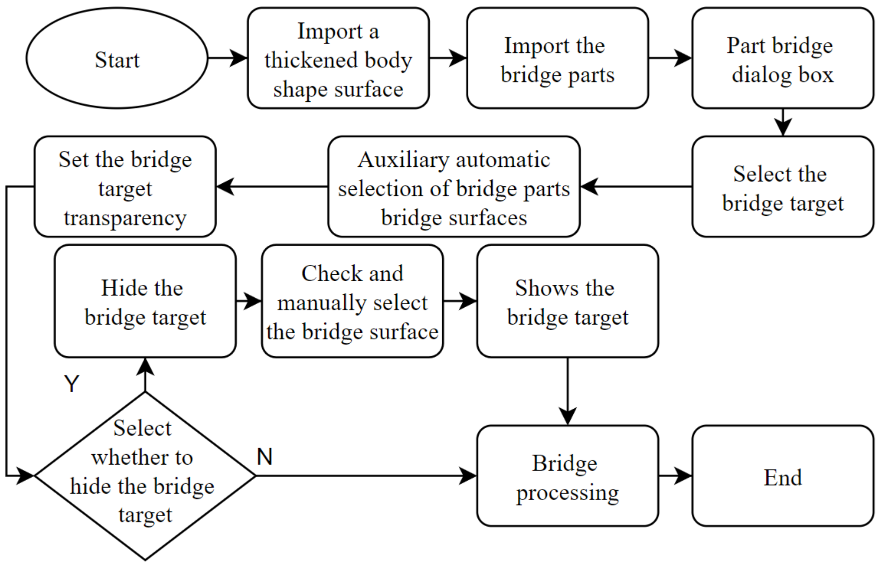
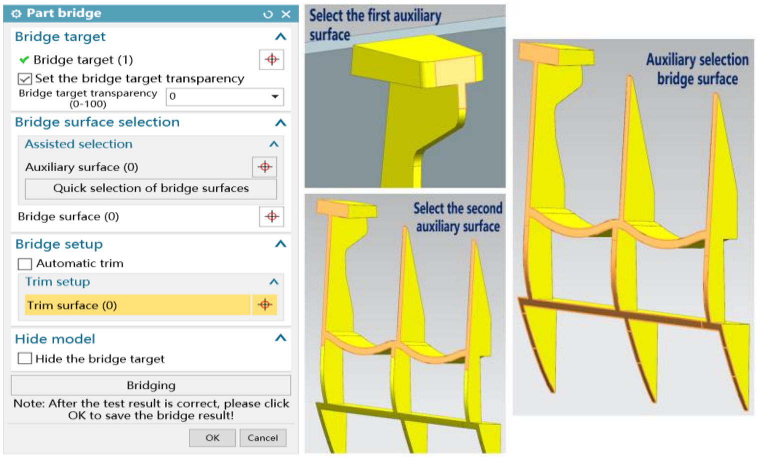


Figure 8: Work flow diagram of parts bridging system

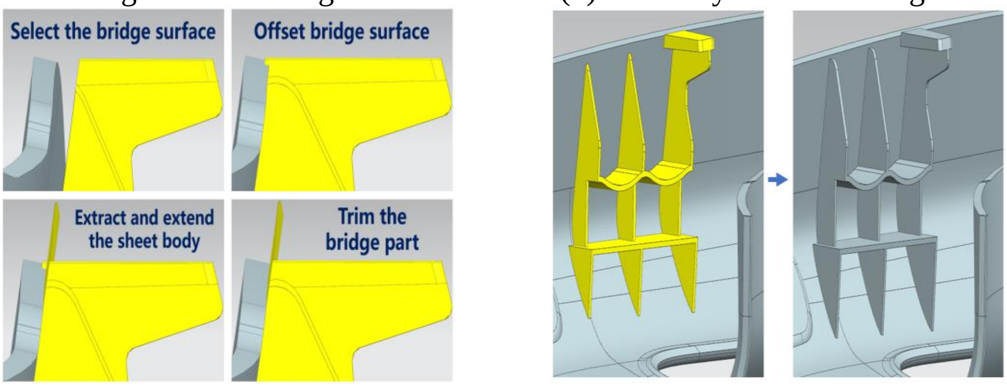
4. Implementation

The following will introduce the specific interactive interface and operation example in detail to verify the effectiveness of this project.

The function of the interactive interface is to facilitate the effective transmission of information between the user and the system. The interactive interface is developed through the NX/Open Block UI tool. The part bridge function is illustrated through the B-pillar trim board car body parts, through the "Part bridge" dialog box in Fig. 9(a); Select the target entity to participate in the bridge, and when selected, the Parts Bridge dialog box refreshes with new parameters for the bridge function. Select the bridge surface of the bridge part. By selecting the "Quick selection of bridge surfaces" button, the auxiliary bridge surface can be selected, as shown in Fig. 9(b), or manually select "Bridge surface" as required, and at the same time, you can choose to hide the bridge target to facilitate the user's manual selection. After confirming that the full bridge surface has been selected, you can also select "Automatic trim" or manual trimming of the bridge surface, and finally click "Bridging" to start the parts bridging process, as shown in Fig.9(c). When the bridge is complete, the bridge target and bridge parts are combined into one entity, as shown in Fig. 9(d). Click " OK", the bridge data is saved and the process is over (if you click "Cancel", the bridge data will not be saved).



(a) Part bridge interface diagram (b) Auxiliary selection bridge surface



(c) Parts bridge processing (d) Bridge completion

Figure 9: Part bridge example diagram

5. Conclusion

This paper relies on UG11 software platform as an application development wizard, uses Microsoft Visual Studio2017 software to write programs, combines NX Open and UFun secondary development technologies, and uses C++ programming language to complete the algorithm design according to the experience and needs of enterprise designers. The automatic bridge function system of vehicle body object and part with interactive interface is developed. The first step of the bridge surface screening is performed by comparing and judging the Angle of the vector rays from the auxiliary surface and other surfaces. Finally, the bridge surface is determined according to the relationship between the farthest line segment from the auxiliary surface and the surface. The maximum projection distance is judged and selected as the bias distance. After the bridge surface is biased, the extended detection and operation are carried out according to whether there is an uninterfered bias surface; after that, the trimming detection and operation are carried out according to whether there are two interference surfaces between the bridge part and the bridge target. Finally, the body target part and the part are merged into a solid bridge. At the same time, the system is used as a plug-in integrated in UG, and users can easily install it on UG for daily use. The system enables rapid automated design and modeling of body parts, bringing substantial efficiency gains.

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