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Secondary Development in the Mid-surface Extraction and Repair of Engine Cover based on Hypermesh

Tongxuan Zong, Zezhong Chen[a], and Jianglin Song

School of Materials and Chemistry, University of Shanghai for Science and Technology, Shanghai 200093, China

[a] 2272314540@qq.com

Abstract

In the pre-processing of sheet metal simulation, the mid-surface extraction and repair process is complex and time-consuming. This article mainly aims at the problems that arise after mid-surface extraction in the pre-processing of sheet metal parts, based on Hypermesh software, using TCL/TK language, and combining with different mid-surface problems that may arise, making a secondary development, writing a script program. And the script program can make an automatic and streamlined processing process, which can realize a series of operations including digital model import, mid-surface extraction, mid-surface repair and automatic mesh file output. Using this program can quickly complete the relevant CAE pre-processing process and improve work efficiency and greatly speed up the progress of simulation analysis.

Keywords

Sheet Metal Parts; CAE; Secondary Development; Mid-surface Repair; TCL/TK Program.

1. Introduction

Sheet metal parts are widely used in electromechanical, light industry, automobile and other industries. The traditional production methods in the past have become less and less suitable for modern design requirements due to the shortcomings of long cycle, low efficiency, and poor quality. CAE Simulation technology can overcome these drawbacks[1]. In the CAE finite element simulation process of sheet metal parts, since the thickness direction of the sheet metal part is very thin, and the dimension of the surface direction is large, it takes a long time to draw the solid mesh directly and is error-prone, so choose to extract the middle surface, and then perform Mesh division to improve the quality of the mesh and improve the accuracy of the simulation. However, in the actual mid-surface extraction process, problems such as partial mid-surface missing, mid-surface discontinuity, and mid-surface overlap often occur. The manual processing steps are cumbersome and the workload is large, which greatly wastes manpower and time[2]. Therefore, it is very necessary to develop a pre-processing program for mid-surface problems to solve the actual needs of enterprises.

Hypermesh is a highly open CAE platform, which has a powerful pre-processing function for finite element meshing. Engineers can use Hypermesh's API (Application Program Interface) interface to compile specific function automation programs according to their own needs to solve different problems. In this regard, existing studies have used the Hypermesh secondary development interface, and applied TCL/TK language to write script programs to establish a custom frame structure analysis pre-processing management platform, which realized format conversion in the pre-processing process, defined the hierarchical relationship between Assembly and Component, The automatic process of defining material properties, loads, working conditions, etc., effectively improves work efficiency and standardization[3]. Zeng Fanfei et al.[4] carried out secondary development of Hypermesh based on TCL/TK language, streamlined the routine modeling operation process commonly used in the simulation analysis process of opening and closing parts, and the report generation process of simulation results, and simplified the original complex and repetitive process. The operation can be completed by one button, which greatly improves the work efficiency of the simulation engineer, and also standardizes the report content and format of the simulation analysis results. Xiao Yun et al.[5] used TCL/TK language to carry out secondary development of Hypermesh software. Using TCL/TK language, an automatic mesh division program was developed based on a mesh division template, and a butt joint transition algorithm was compiled to realize a visual interface operation.

This paper mainly combines the problems encountered in the pre-processing process of sheet metal parts, based on Hypermesh software, using TCL/TK script language to write an automation program for the pre-processing process of sheet metal parts. And the automation program includes digital model import, mid-surface extraction, mid-surface repair and automatic grid file output, using this program can quickly complete the relevant CAE pre-processing process, which not only improves work efficiency, greatly speeds up the progress of simulation analysis, but also facilitates the automation and standardization of the pre-processing process of sheet metal parts.

2. Introduction to the Secondary Development Language TCL/TK

TCL (Tool Command Language) is an easy-to-use and easy-to-extend embedded scripting language, which is often used in rapid prototyping, scripting, GUI and testing[6-8]. It can issue commands to interactive programs (such as text editors, debuggers), and complete automated batch processing, and is applicable to various platforms including Windows, Unix, Macintosh, etc. The biggest feature of TCL language that is different from other languages is: TCL program is composed of TCL command sequence, and each statement is an instruction.

Due to its extremely easy-to-extend feature, TCL has a large number of extensions written in C/C++ to provide functions that TCL itself does not have. Among them, the most widely used extension is TK, which provides graphical user interface GUIs under various OS platforms (even the powerful Python language does not provide its own GUI alone, but provides an interface to adapt to TK).

Hypermesh software comes with an interface of TCL scripting language. By calling the API (Application Program Interface) interface function based on TCL/TK language provided by the software, the code is written and the CAE analysis process is customized[9]. Hypermesh contains four main functions in the pre-processor, including TCL GUI (graphical user interface) function, TCL Modify function, TCL Query function, and macro menu function, seamlessly connecting TCL/TK language[10]. Engineers can develop various functions according to their own work needs, improve the efficiency and accuracy of CAE analysis, and shorten the development cycle[11].

3. Implementation of Secondary Development Automation

3.1 Command Acquisition

Hypermesh is a powerful CAE pre-processing software and provides a good secondary development environment, which provides a good solution for some problems with repetitive operations. In the Hypermesh software, all user operations on the model are recorded in the command file[12]. Users only need to access the command file to obtain the corresponding operation commands according to their secondary development needs, and use the TCL language to execute the commands according to certain requirements. The logic of the program is connected in series to form a script program with a specific function. In this way, it is only necessary to call and run the script program during the pre-processing.

3.2 Problem Analysis

In the actual pre-processing process of sheet metal parts, by extracting the mid-surface of the sheet metal model and then dividing the mesh based on the mid-surface, it can not only improve the pre-processing time of CAE, but also improve the quality of the model mesh and thus improve the

 Volume 9 Issue 3, 2023
DOI: 10.6919/ICJE.202303_9(3).0013

accuracy of CAE analysis. However, usually due to the complex surface configuration of sheet metal parts, various problems often occur after extracting the mid-surface. The problems such as the partial missing of the mid-surface, which is common in parts with scale lines such as fenders; the mid-surface is discontinuous, and it is more common in complex curved surfaces; the middle surfaces overlap, and the profiles with bosses often appear.

3.3 Human-computer Interaction Interface Establishment

In view of the problems that may arise after the mid-surface extraction of the sheet metal parts, processes such as mid-surface pre-cleaning, defective surface repair, free edge gap stitching, and overlapping surface deletion are added. In addition, the processes of automatic model import, mid-surface extraction, and mid-surface grid division can also make the entire CAE mid-surface mesh process more automated. According to this process, users can complete a series of process operations such as model import, mid-surface automatic extraction, mid-surface repair, and mid-surface automatic meshing, which is easy to operate and saves time and effort. Figure 1 below is the flow chart of CAE analysis.

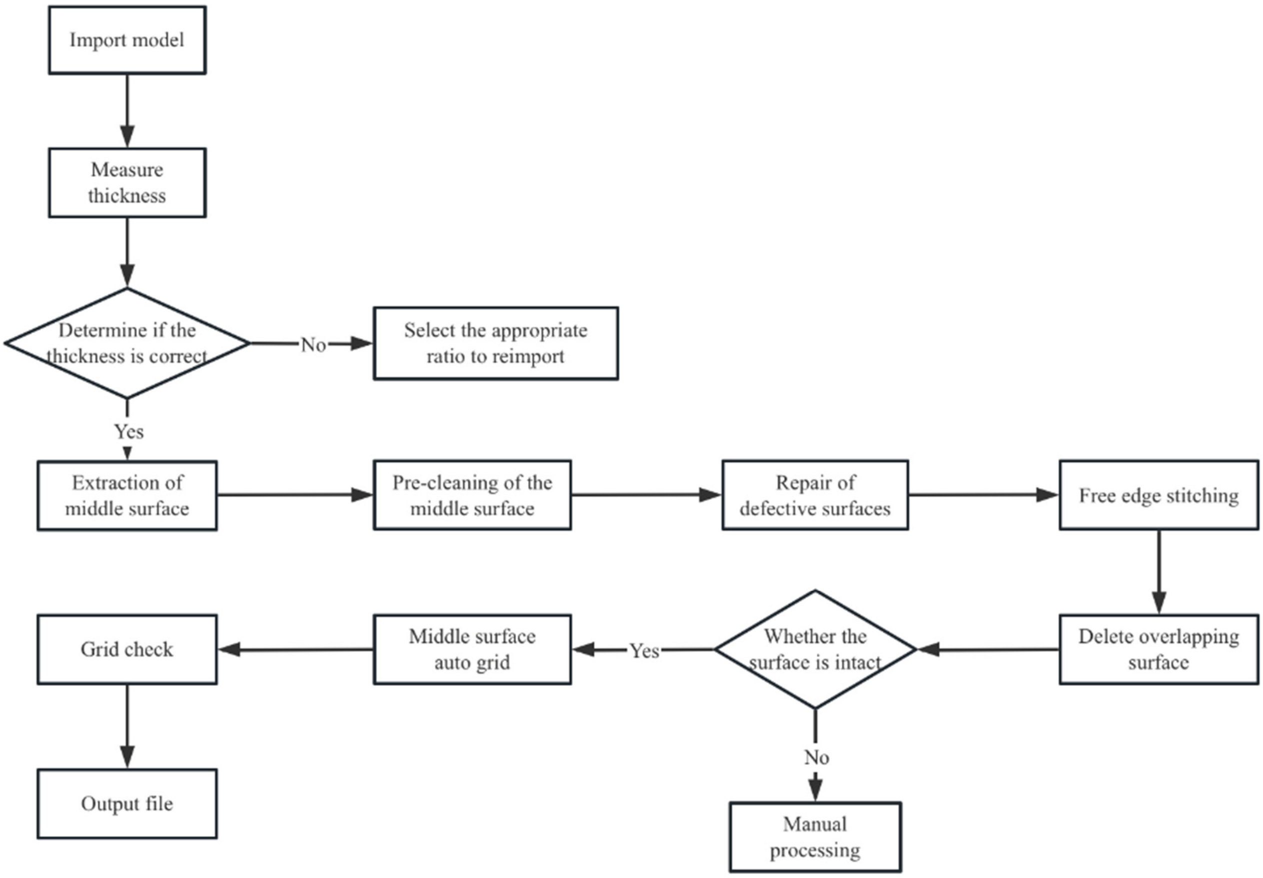

Figure 1. CAE pre-processing flow

According to the CAE pre-processing flow chart, the Graphical User Interface shown in Figure 2 is designed. The GUI user interface is mainly composed of three parts: the first part is the import of the model and the automatic extraction of the mid-surface; the second part is the mid-surface cleaning, which includes Mid-surface pre-cleaning, defective surface repair, free edge batch stitching, duplicate surface deletion, and mid-surface surface editing; the third part is mid-surface automatic meshing, mesh quality inspection, and mesh file output. Users can complete a series of operations from geometric model import to mid-surface extraction to mid-surface repair and grid file output according to the GUI interface process, which greatly improves work efficiency and speeds up the progress of simulation analysis.

 Volume 9 Issue 3, 2023
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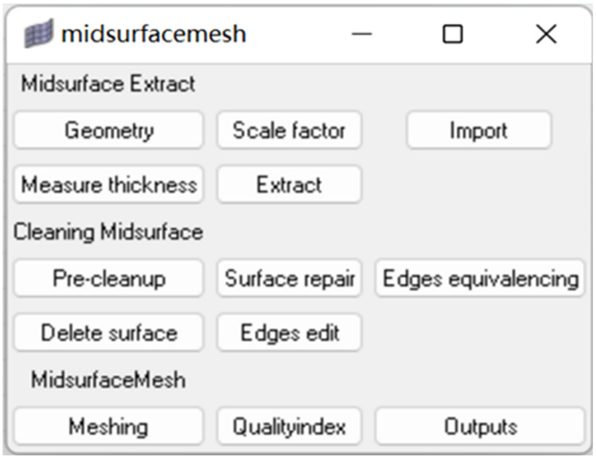

Figure 2. Graphical User Interface

4. Automated Process Development

4.1 Model Import and Surface Extraction

4.1.1 Model Import

The digital model used in this paper is the outer panel of the automobile engine, as shown in Figure 3 below. Using UG software to save the digital model file in IGES format, clicking the "Geometry" button to complete the digital model selection, and the "Scale factor" button can customize the appropriate scaling ratio, and the selection of the scaling factor will directly affect the digital model size, and finally clicking "Import" to complete the import of the digital model.

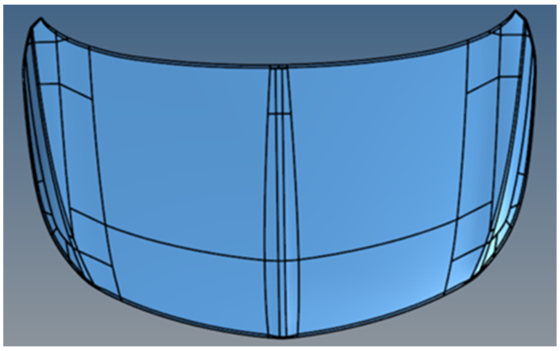

Figure 3. Two or more references

At the same time, the "Measure Thinckness" button is also formulated, which is convenient for users to conduct a preliminary inspection of the size and thickness of the data model, judge whether the size of the digital model meets the design requirements, and facilitate subsequent pre-processing operations. As shown in Figure 2 above, "Geometry", "Scale factor", "Import" and "Measure Thinckness" represent digital-analog selection, scaling, digital-analog import and measurement thickness respectively. Fig. 4 is a schematic diagram of a GUI interface for customizing the scaling ratio.

Figure 4. Schematic diagram of scale input

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4.1.2 Mid-surface Extraction

Add the button "Extract" to extract the middle surface. Click "Extract" to complete the automatic extraction of the middle surface and display the currently extracted middle surface separately for the subsequent cleaning steps of the middle surface. The principle is to select all the faces to be extracted at one time, and the software automatically recognizes the faces parallel to each other, automatically extracts and sews the middle faces. Figure 5 below shows the mid-surface model after extracting the mid-surface.

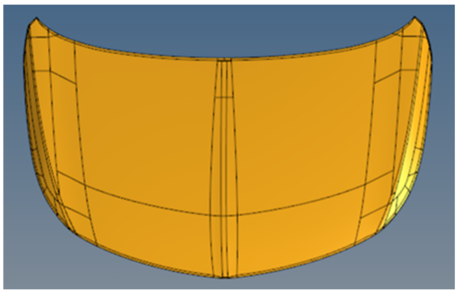

Figure 5. The mid-surface model after extracting the mid-surface

4.2 Mid-surface Cleaning

4.2.1 Pre-cleaning of Mid-surface

After the middle surface of the digital model is extracted, many wrong surfaces and lines often appear on the middle surface. The number of errors is large and the processing is time-consuming and laborious. However, Hypermesh has its own automatic cleaning function "autocleanup" in the "Geom" panel. Through transplant the command to it, add the "Pre-cleanup" command pre-cleaning function, make it automatically run the "autocleanup" command, complete the preliminary mid-surface cleaning task, which can eliminate most of the wrong surfaces and lines on the mid-surface.

4.2.2 Mid-surface Repairing

Click the "Surface repair" button for the defective surface, and the software will automatically pop up the interface for repairing the missing surface. By clicking on the A and B sides that need to be repaired on the digital model, the defective surface can be repaired. Figure 6 below is the defect surface repair interface.

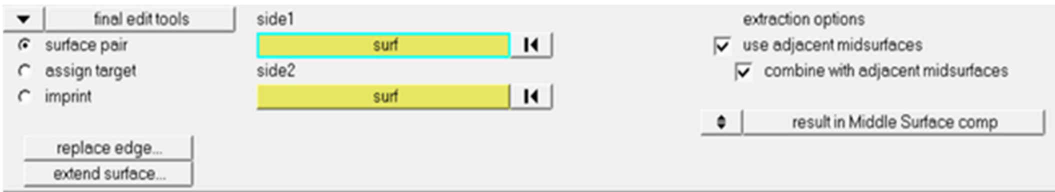

Figure 6. Schematic diagram of the defect surface repair interface

For some small and imperceptible gaps, click the "Edges equivalencing" button and customize the input gap tolerance to realize the batch automatic stitching of two free edges within the tolerance, and realize the repair of small defect surfaces. Figure 7 below is the custom gap tolerance interface.

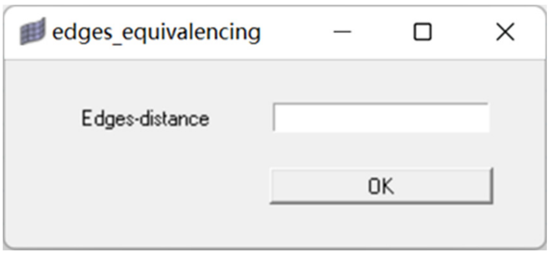

Figure 7. Schematic diagram of gap tolerance input

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4.2.3 Overlapping Surface Deletion and Mid-Surface Editing

When encountering some overlapping surfaces, you can delete them by clicking "Delete surface" and selecting the redundant surfaces at the corresponding error in the model. In addition, the button of "Edges edit" is added for some problems that cannot be automatically solved by the process. "Edges edit" adopts the [hm_pushpanel] command of the command in Hypermesh to transplant the buttons. In the "Edges edit" interface, you can use a variety of tools that come with the Hypermesh software Edit the model boundary and surface, such as "split surf-nod/line" (split surface) can divide a complex surface into multiple regular surfaces, improve the quality of the divided mesh, "washer split" can cut the surface by generating offset line segments at a specified distance. Besides at the fillet that does not affect the strength of the part, "trim-intersect" (remove the edge chamfer) can make the fillet into a sharp corner to ensure the quality of the mesh. Figure 8 below is the operation interface after clicking the "Edges edit" button.

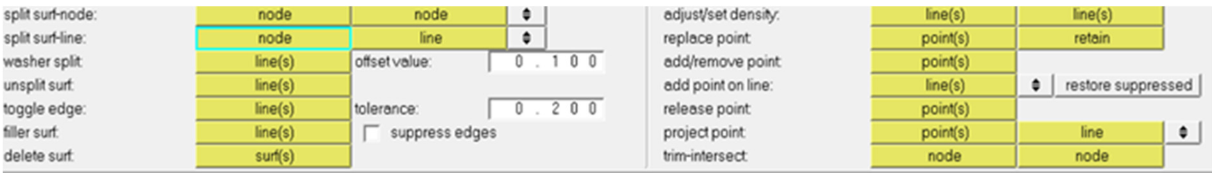

Figure 8. Schematic diagram of surface editing interface

4.3 Mid-surface Automatic Meshing and Mesh File Output

After the middle surface is cleaned, click "Meshing" to automatically mesh with one button. The quality of the mesh after the mesh division is completed directly affects the accuracy of the simulation results. Among them, the parts corresponding to the mesh with poor quality have poor simulation performance and cannot reflect the real situation of the parts accurately, which may also greatly prolong the simulation analysis time.

Therefore, it is necessary to check the grid quality and optimize the unqualified grid parts. Checking the mesh model and optimizing the mesh quality by using the button of "Qualityindex". At this point, the meshing operation is completed, and click "Qutputs" to output the mid-surface mesh file. Figure 9 below shows the mid-surface mesh model after the automatic mesh division is completed.

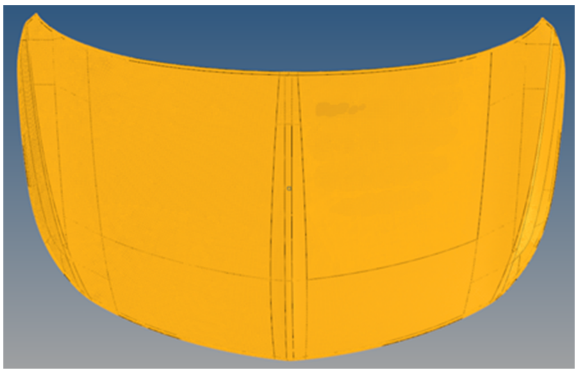

Figure 9. Mid-surface mesh model

5. Conclusion

This paper mainly focuses on the secondary development based on Hypermesh software for the CAE pre-processing process of sheet metal parts, and the entire process designed is automated and standardized. By using the secondary development script program, most of the problems encountered after extracting the middle surface of sheet metal parts can be solved, greatly improving the pre-processing speed of sheet metal parts, saving a lot of time and improving work efficiency. At the

ISSN: 2414-1895 DOI: 10.6919/ICJE.202303_9(3).0013

same time, the script program for mid-surface cleaning also provides convenience for engineers to solve mid-surface problems.

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