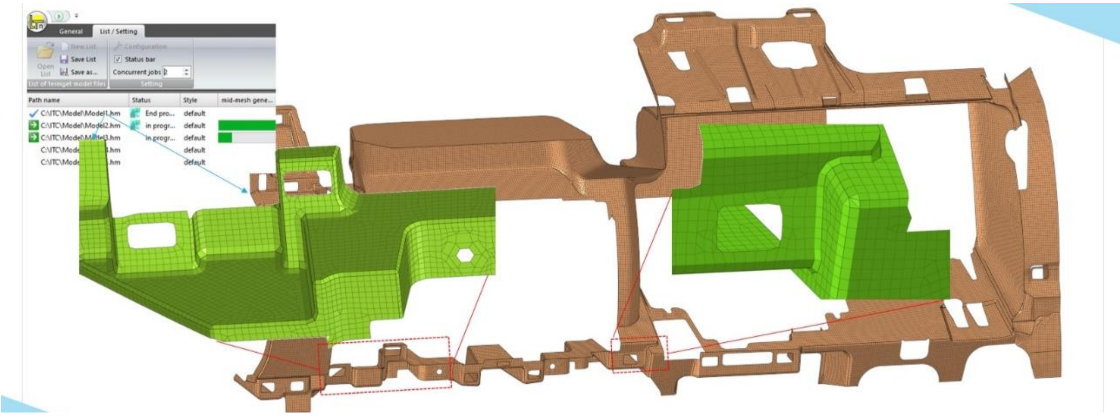
UNATTENDED OPERATION OF MID-SURFACE GENERATION TOOL FOR BOOSTING EFFICIENCY IN CAE PRE-PROCESSING

Sumadi Jien - General Manager, Integral Technology Co., Ltd. & Altair APA Team / August 6, 2025



Abstract

Automatic mid-surface tools to convert any 3D objects into mid-surface representation have been a common practice for modeling in Computer-aided Engineering (CAE) simulation. In fact, automation of mid-surface extraction process was perceived as a breakthrough in CAE pre-processing that has significantly eliminated the tedious works of creating simulation models. Despite the great gain in the automated mid-surface modeling, it doesn't always give out satisfactory results especially for 3D objects with high complexities. Manual works are necessary to repair the imperfection of the inferior results output from the automatic mid-surface extraction process, thus causing inefficiency. To cope with these problems, LATONA was developed as an alternative tool for automatic mid-surface generators with less pain in repair tasks. In addition, LATONA serves to automatically set the load/boundary conditions that are absolutely required for CAE analysis, which is expected to improve the overall efficiency of CAE process.

Introduction

The role of CAE simulation in product design can be broadly defined as threefold: 1) Virtual testing to cut costs/reduce prototyping iterations, 2) Shortening design lead-time to bring products to market faster, 3) Enhancing product quality and innovation in product development. From this perspective, time, cost and quality are vital in CAE simulation and must be considered carefully. Optimization of these three factors requires high expertise in design know-hows and digital simulation skills to make good decision within the designated delivery time. Recently, as prices keep rising and unavoidable workforce shortages, software automation becomes indispensable to help reduce the workload of product designers/analysts.

This paper is written to cover the topic on how to boost efficiency of mid-surface modelling in CAE simulation. As widely known, mid-surface generation from 3D objects hasn't been easy for many years and at the early stage of creating mid-surface models manually CAD models must go through several treatments, i.e., simplification, defeaturing, suppression before performing the mid-surface extraction process [1]. As time elapsed and through the advancement of CAD-CAE integration, mid-surface extraction tools have been developed to automatically convert any 3D objects into mid-surfaces [2-7]. This mid-surface extraction function is now available in both CAD and CAE software. Research works and new developments to find better mid-surfacing algorithms are still undergoing to obtain better results and to find potential applications in diverse areas [8].

Automation of mid-surface has laid the foundation for the future CAD-CAE integration. In the past few decades, mid-surface extraction tools have been used mainly by analyst experts in CAE domain and to boost up design cycle product designers who literally work solely in CAD domain are expected to be able to perform simple CAE simulation.

Hereby, automatic mid-surface generation tools with high efficiency and accurate results will become much more important in the future.

Although mid-surfacing has been automated, however, the generated mid-surface results are not always completely ready for use in CAE analysis. To create analysis-ready models, manual edit is involved in fixing the mid-surface results that have defects. The time spent on manual work can vary depending on the complexity of 3D geometry, model size, etc. Manual labor can be so exhausting especially for complicated objects of large sizes, and in some cases the mid-surface results may be too bad and difficult to repair. Depending on the failure levels, in some cases it is even easier to build the mid-surface models all over again from scratch. As an accepted common practice in building mid-surface models from scratch, mid-surface is extracted by offsetting the outer surfaces of an 3D object into the mid-position, which is considered as the easiest and most robust method.

Based on the above-mentioned offset methodology, a new system was proposed here as an alternative/replacement tool to help ease the burdens of product designers/analysts. The development of this new tool focuses on integration, robustness, interactive edit functions and the potential for extended applications. Integration and robustness are closely related to simulation accuracy, while the interactive edit function is essential to improve efficiency of manual work during the preparation of mid-surface models. This interactive edit menu is necessary to make it accepted as a user-friendly application. To further enhance the simulation efficiency, this new tool is not limited to generating mid-surface only but also touch on improving efficiency in other aspects of CAE simulation process. Finally, the proposed tool can be used as an alternative option when the currently existing tools give poor outcome, or as a completely unmanned automatic tool that runs by itself without human operators.

The challenges of mid-surface modelling for CAE analysis

To find out what causes the inefficiency in creating mid-surface model for CAE analysis, we can think of two words: automation or inferior results. If it hasn't been automated, the answer is to introduce automation, and if it has been automated but has poor results then the remedy is to build new algorithms that will give better results. Since mid-surface generation process has been automated, here come up two different approaches for improving efficiency: 1) to reduce/eliminate the manual work, 2) to reduce the total time necessary for mid-surface model preparation. The focus of this paper is to reduce the manual work and help ease the burdens in mid-surface generation rather than time-efficiency. After the problem of manual work is solved, then time-efficiency is the next topic for the future.

Let's look at where the manual work takes place and what can be done to reduce/eliminate them. Table 1. shows the estimation of efficiency rate of CAE pre-processing derived from practical observations. Mid-surface extraction for simple geometry like sheet-metal products with constant thickness has relatively high efficiency, but in contrary manual repair are still needed for more complicated products and therefore is considered ineffective. At the present time wall thickness measurement has been fully automatic, however, there are some features/areas inside an object that must be calculated differently such as tapers or steps. This indicates that wall thickness measurement process still requires manual work at some point and is not completely automatic. The other tasks of CAE pre-processing are perceived as low efficiency in the context that they are difficult to automate and highly dependent on manual labor.

Full automation for these tasks requires the recognition of certain parts/exact location on where to apply the mesh rules or load/boundary constraints. Part/feature recognition is one challenge that must be handled before going on to automation. Fig. 1 gives an illustration for recognition of parts/connectors in assembly models and features/shapes in part models for use with mesh rules. For assembly models, mesh modelling is primarily different for parts and connectors, so this differentiation becomes compulsory. For part model that is subjected to mesh rules, application of mesh rules differs between features so there is a necessity for the recognition of various features.

As elaborated earlier, the current automatic tools for mid-surface generation are facing a variety of problems and difficulties. To launch a fully automated mid-surface modeling for CAE pre-processing, several problems that need an immediate solution are as follows: 1) better algorithm for improved results, customizable functions to tackle with special needs, and 2) feature recognition for mesh rules/assembly models.

No.	Pre-processing task	Efficiency
1	Mid-surface extraction	×～○
2	Wall thickness measurement	△～○
3	Material, load/boundary settings	×
4	Assembly modeling	×～⊿
5	Adaptivity to mesh rules	×～⊿

Table 1 - The estimated efficiency rate of CAE pre-processing tasks from observations (× : low, ⊿ : medium,○ : high)

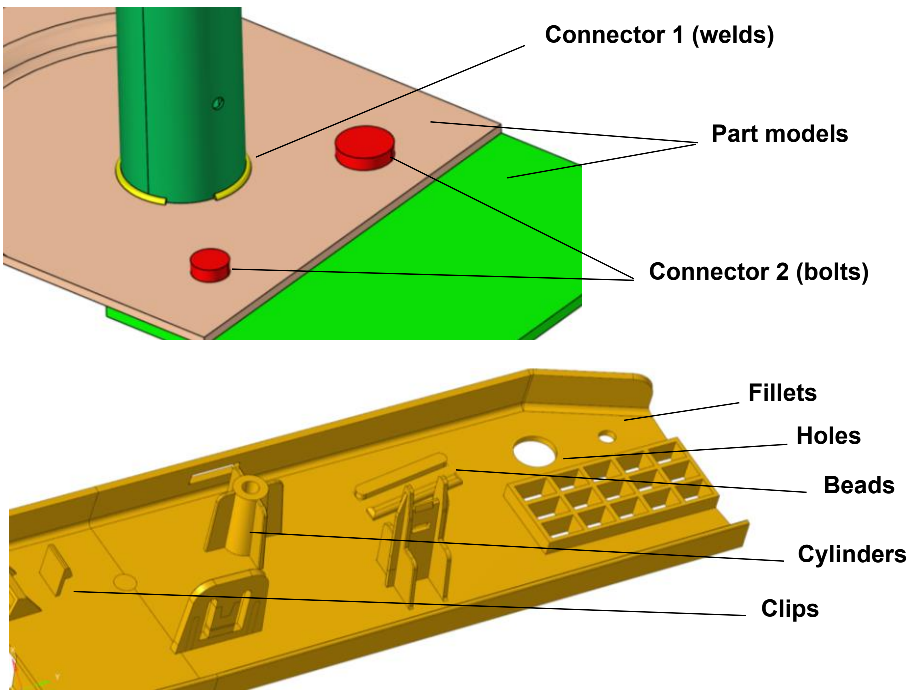


Figure 1 - Recognition in assembly/part models that is necessary for the automation of CAE pre-processing tasks

LATONA - User-friendly tool for improved efficiency in mid-surface modelling

To solve the challenges of mid-surface extraction for thin-walled objects such as sheet metals or resin products, an automatic tool LATONA was designed to have feature recognition module and a different approach in extracting mid-surface, which has one sole purpose to help improve the modeling efficiency. The conceptual framework and validation of the proposed system can be found in [9]. LATONA itself works under CAE software platform HyperWorks and has access into HyperMesh through API commands. Fig. 2 shows the overall architecture of LATONA system with input as 3D geometry data and output as mid-mesh results. LATONA has complete handling over the whole framework while it is linked to HyperMesh platform and uses the basic functions provided through API commands to complete certain tasks. The main benefit offered by LATONA is unattended operation where it serves as a robotic tool to replace the human operators (Fig. 3). LATONA possesses feature recognition and mesh control modules that enable it to function like what human operator can do.

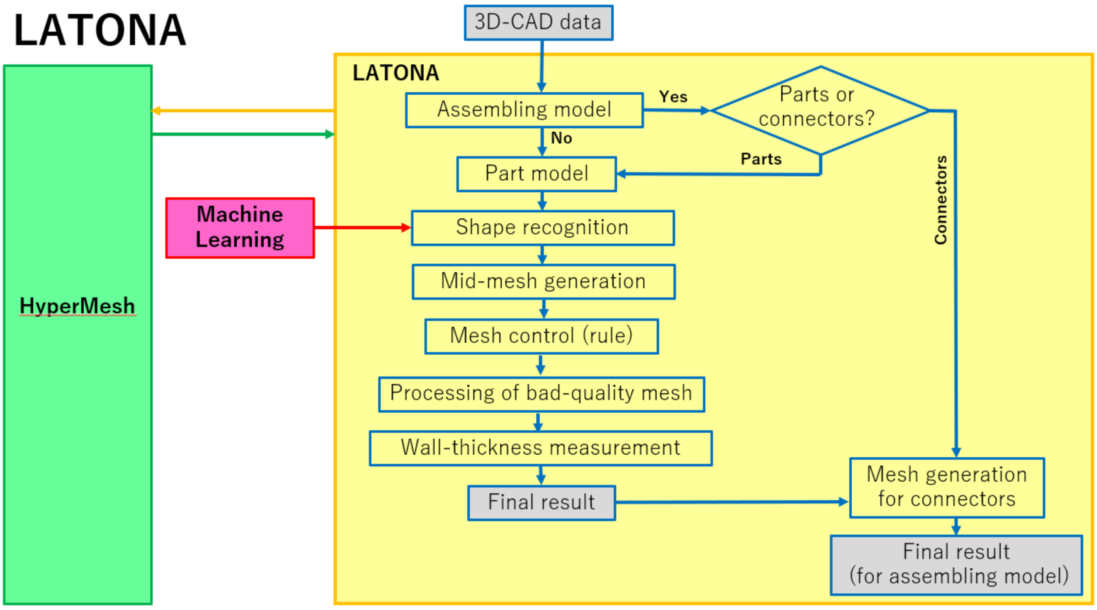


Figure 2 - Overall structural diagram of LATONA

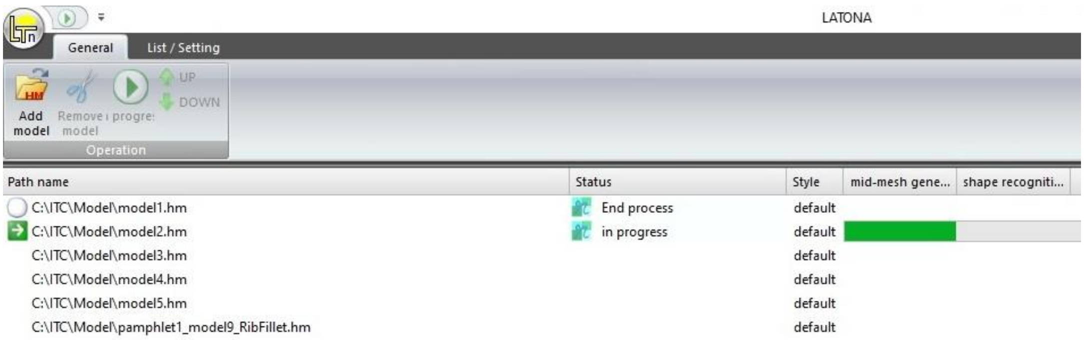


Figure 3 - Unattended operation and parallel processing to get more jobs done automatically

The newest LATONA version is equipped with pre-trained Machine Learning (ML) for feature recognition (see Fig. 2). Using ML to recognize features allows re-training with more input data that will result in higher accuracy. In other words, the users will gain more flexibility and freedom in feature recognition using ML to recognize various types of 3D objects. ML has an adaptation ability to recognize any specific objects with good accuracy through re-training / update. Re-training can be executed freely by the users using several 3D objects. LATONA offers sub-module “LATONA_training” for the purpose of re-training process, and it is as easy as registering new input data (Fig. 4).

To ease the burdens on manually editing the mid-surface defects that may occur, LATONA offers a user-friendly function during the automation process, where users are allowed to intervene in the automation process and make any corrections in an easy way. LATONA provides two operation modes: full-automatic and semi-automatic mode. Using semi-automatic operation mode, users are allowed to intervene during the automation process. It is at the users’ choices to stop the process midway, manually make any necessary correction and resume the process again (Fig. 5). Semi-automatic mode gives better results with easy correction tasks and user-friendly menu.

Figure 4 - Re-training of Machine Learning model using “LATONA training”

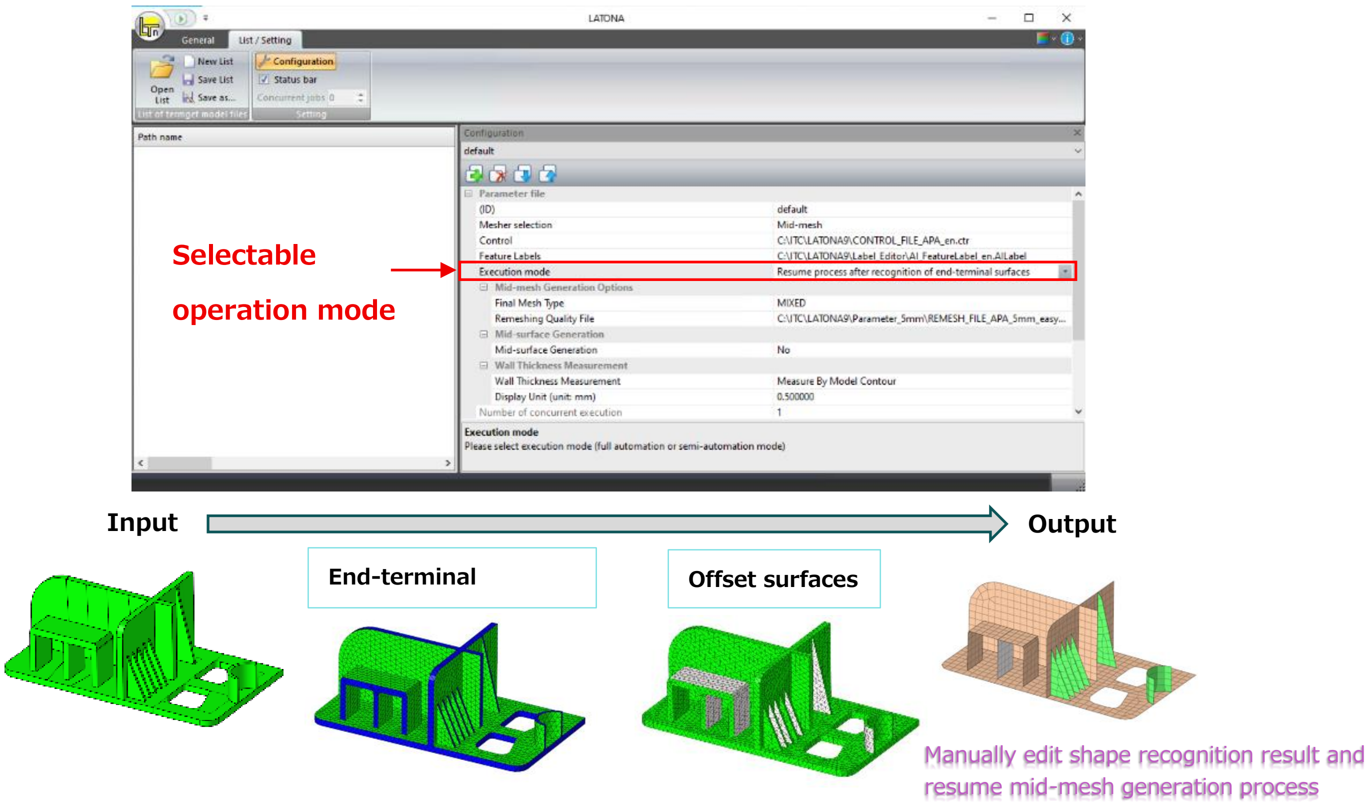


Figure 5 - User-friendly automatic tool with selectable operation mode

Applications of LATONA

Comparison of this proposed tool and the existing mid-surface generators have both advantages and disadvantages. The currently available tools may provide good enough results with less manual work in certain industries and considered to be sufficient for their usage in automated CAE simulation. On the other hand, not all industries may enjoy the benefits provided by the existing automated mid-surface tools. While not satisfied with the current results, bored with the tedious manual repair work, or for industries that are still looking for improvement and better efficiency of mid-surface extraction tools, LATONA may offer a quick solution to reduce the burdens in preparing CAE models. Few implementations of LATONA being tested and proved to be effective in real world applications are given as follows:

Unattended operation

LATONA runs automatically all by itself and will replace the necessity of human existence in operating mid-surface generating software (see Fig. 5). LATONA can be executed as an automated robot during midnight hours where human operators are at rest, enabling the mid-surface generation process to work 24 hours a day continually. This will absolutely bring time-saving advantages for designers/analyst experts to meet the strict development/design time limit.

Modelling for objects with varied thickness (stacked plates)

As widely known the currently existing tools are not suitable for extracting mid-surfaces for objects consisting of stacked plates, which basically output unsatisfactory results at most times. On the other hand, LATONA, that employs offset methodology similar to the manual process conducted by human operators has been proved to be able to give better and robust results compared to other mid-surface generation tools.

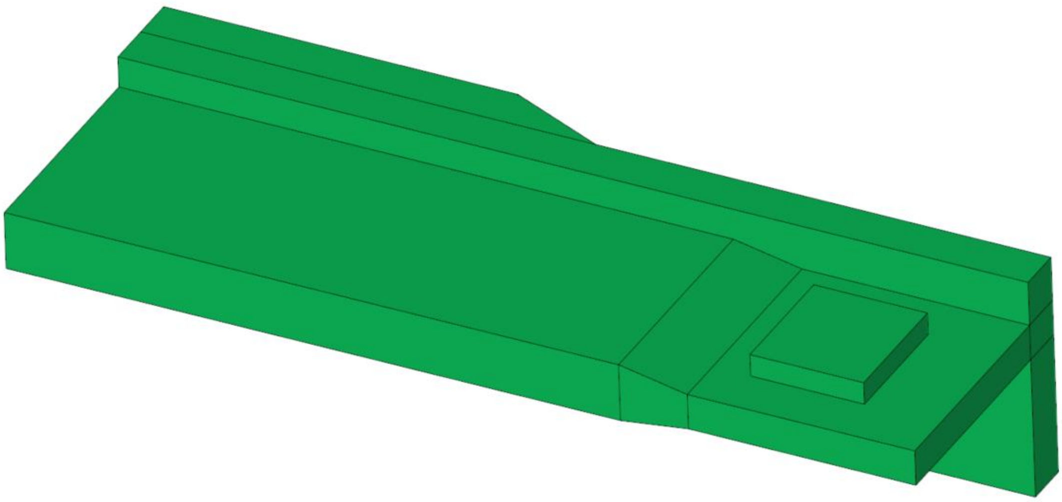


Figure 6 - An example of stacked-plate model

Special handling in mid-surface generation process

Automatic mid-surface generation tools that are currently available have an algorithm to seek the mid-position of thin-walled objects as the answer for the mid-surface. In real applications, depending on the type of simulations there are many cases where the mid-position isn't the only correct solution. When mid-position isn't the expected answer, manual repair work is unavoidable and so time-consuming. LATONA that generates the mid-surface by offsetting the outer surfaces, is found to be more effective for such a special need in handling mid-surface generation. Moreover, LATONA has full control of mid-surface offset that can be adjusted to meet with various requirements of mid-surface modeling.

Crash simulation

Minimum mesh size error is very important in crash analysis, which has to be kept under a certain level for the simulation to run properly. To manually edit the mesh error is time-consuming and oftentimes involves repetitive manual work. The difficulty in attempting to automate these repetitive manual works is because most of the mesh errors are related to any constraints of geometry lines that have to kept in general. To create good quality mesh in the vicinity of geometry lines involves the know-how on how to omit/move the geometry lines that is not easy to be automated and mostly has to be done manually. To solve this problem, LATONA was designed to have the capabilities of handling both the geometry lines and mesh quality at the same time, which is useful for omitting the unwanted geometry lines and ensuring good quality meshes are generated for crash simulation.

Assembly modeling

An assembly model consists of parts and connectors with different ways of modelling. The parts are modelled as mid-surface while the connectors are basically modelled with 1D lines or solid meshes. Most of the existing mid-surfacing tools are helpful in generating mid-surface for the parts only and are not applicable to create the modeling for connectors. Mostly the modelling of connectors must be done manually and there is plenty of room for improvement. To help improve the efficiency of assembly modeling, LATONA was designed to be able to handle the modelling for both parts and connectors simultaneously. This will bring a huge impact to reduce the burdens of model creation for connectors that have to be done by hand previously.

The authors believe that there are still rooms for LATONA implementations in many other sectors other than the above-mentioned applications. LATONA has its best use, especially for simulations that require special control/handlings for the mid-surface generation process that are not available in the existing tools. The obvious point of LATONA is that it can be adjustable to meet the clients' demands for controlling mid-surface models. For those that are seeking improvements, higher efficiency in CAE pre-processing, LATONA offers the integration of mid-surface generation, mesh control, wall thickness measurement, and settings for material properties & load/boundary conditions. LATONA is a fully automated tool that can directly create analysis-ready modelling for CAE simulations with less manual work.

To facilitate mid-mesh modelling in various industries with more options and better efficiency, LATONA is now available in Altair Partner Alliance (APA) marketplace. As part of APA, it opens access to worldwide users globally and in addition to that, LATONA runs on Altair units making it easier to implement. The feedback/improvement plans provided by different industries from global perspective will absolutely help LATONA to continue development and answer the future challenges in CAE pre-processing domain.

Future Improvement

Throughout all the benefits that can be offered by offset methodology in LATONA, it also has some drawbacks. This offset method was verified to be useable for the majority of thin walled objected such as metal casting/resin products, but unfortunately there are shapes that seem not to match well with offset methodology. As an extended applications for the next updates, LATONA will be equipped with Artificial Intelligence (AI) dedicated to meshing purpose. This new AI module for meshing will allow a direct generation of mid-surface shapes that do not work well with offset algorithms. Overall, this hybrid method of offset and AI for meshing is expected to have better performance for the future.

Conclusion

CAE simulation using mid-surface modeling poses challenges in manual edit labor and is still seeking for improved efficiency. LATONA offers user-friendly and easy operation mode that will help novice and experienced users to reduce their workloads. In addition, LATONA is equipped with Machine Learning modules and has high potential for customization to meet any specialized requirements in mid-surface modelling, which will contribute to significant improvement in efficiency and accuracy.

References

[1] Yogesh H., et. al, "Using Features for Generation of Midsurface", Proc. Of Int. Conf. on Advances in Mechanical Engineering, ICAME May 2013

[2] https://www.youtube.com/watch?v=WeeU5x8zpWo

[3]https://innovationspace.ansys.com/knowledge/forums/topic/extract-and-edit-mid-surface-in-spaceclaim/

[4]https://www.youtube.com/watch?v=iJdw2e6o6NY&list=PL1m1vu8_quoB_Eo2aGL2dpYXs2AQG9OXV&index=1

[5] https://www.youtube.com/watch?v=EtdB83PtvQ8

[6]https://simulatemore.mscsoftware.com/introduction-midsurface-geometry-and-meshing-for-fea-with-msc-apex/

[7] https://www.youtube.com/watch?v=WnO2BJDxLKc

[8] Eva Bones, et.al., "MidSurfer: A Parameter-Free Approach for Mid-Surface Extraction from Segmented Volumetric Data", April 2024, https://doi.org/10.48550/arXiv.2405.19339

[9] Jien, S., Nishiura, H., "Automatic Tool for Improving the Meshing Efficiency for Thin-Walled Objects – Mid-Surface Mesh Generation Utilizing Shape Recognition", SAE Int. Journal Material Manufacturing 11(4):361-372, 2018, https://doi.org/10.4271/2018-01-0478