Proceedings of International Conference on Advances in Mechanical Engineering
May 29-31, 2013, COEP, Pune, Maharashtra, India
ICAME2013 **S2 9**

USING FEATURES FOR GENERATION OF MIDSURFACE

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ABSTRACT

Data provided by CAD (Computer Aided Design) models is often not suitable for CAE (Computer Aided Engineering) operations like meshing. Some geometric-topological features are irrelevant and suppression of them does not harm accuracy of the analysis-result to a large extent, but in turn provides significant leverage in terms of processing time-space. Thus CAD models are often simplified-abstracted-idealized to suit needs of CAE analysis. One of the prominent simplification techniques is called Midsurface which is highly suitable for thin walled parts prevalent in plastics and sheet metal domain. Thin portions of the model are idealized to surface along with thickness data later to be used for modeling Shell elements. Midsurfacing techniques have been researched for past few decades. Many commercial CAD-CAE applications have midsurfacing capability. Apart from CAE, midsurface has found applications in Visualization, Animation, Feature Recognition etc. as well.

This paper proposes a framework for generating connected-midsurface in the feature-based modeling environment. The proposed framework will be based on non-manifold topology and will cater to features prominent in thin wall parts typically used in Sheet Metal CAD applications.

INTRODUCTION

Midsurface is an abstraction for thin-walled portions. Shell elements, based on midsurface, will give sufficiently close analysis results compared to that of 3D Solid elements. ’Thin Wall’ is an inherent characteristic of the Sheet Metal parts and thus this work will cater to features prominent in Sheet Metal CAD applications. Midsurface can be used in thin portions of usual/mixed-dimensional/thick-thin parts also, but there, one needs to work out treatment of interfaces/joints/couplings which is considered out-of-scope for the current research. Midsurface is expected to have proper connectivity (no gaps) and it should follow shape of the base part. As midsurface is generated Face-Pair wise, it needs to be stitched together to form a continuous shape. In midsurfacing techniques, there are two broad categories namely ’Medial Axis Transform (MAT)’ and ’Midsurface Abstraction (MA)’.

MAT is locus of the center of an inscribed disc of maximal diameter as it rolls around the object interior. The associated radius function gives radius of the inscribed circle at every point on the skeleton, and makes the original 2D object recoverable from the medial axis. In 2D it’s called Medial Axis Curve (Figure 1) whereas in 3D it is called Medial Surface. Major drawback of this method is that it creates unnecessary branches and its shape is smaller than the original corresponding faces. Plus there is major issue of perturbations, meaning slight change in the base geometry forces re-computation of MAT and the result could very well be different than the original.

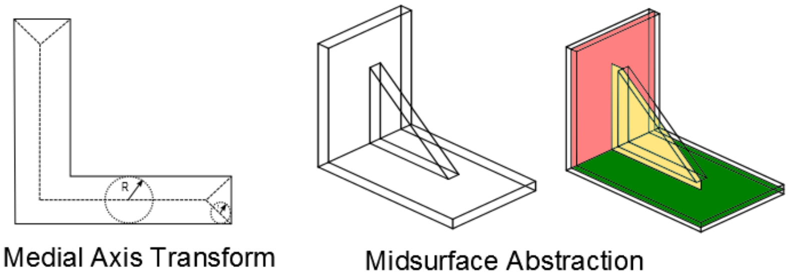

Figure 1: Midsurface Extraction methods

Instead of basing the construction on the information contained in the feature model, the geometry as a whole is analyzed and then a global abstracted shape is derived, commonly based on the medial surface, medial axis, or a similar skeletal structure. In this process, however, the connection of the analysis geometry with the features, the corresponding semantics, and the constraints that define the design model, is lost [2].

Both the above mentioned techniques are based on extraction where algorithm is applied on the final share. Many a times, due to complexity in recognizing forms, and due to complex interactions between them, midsurface of the part does not follow its form and is not fully connected [3, 4]. Solution could be, to create midsurface while building the model itself.

In Features-based Solid Modeling, input feature-parameters are used to build tool-bodies and the whole part gets built using direct or indirect boolean of base and tool bodies. Creating midsurface for individual tool bodies appears to be a more deterministic problem than recognizing the feature forms. With well-defined boolean operations, correct midsurface connectivity can be ensured. To the best of author's knowledge and during the literature review done so far, such system was not found either in the academic research or in the commercial applications.

LITERATURE REVIEW

Good amount of research has been done in both approaches MAT and MA, but for different application domains. Midsurface is commercially available in many CAD/CAE packages. What's lacking in them is the usage of feature information. Various reasons for not using the feature-information are access-restrictions to the proprietary feature information, unsuitable non-manifold structure, as well as impracticality to include CAE structures in CAD software. There has been some work using M-Rep (Medial Representation similar to B-rep) which uses Medial entities as data model. But it has very basic data model and is mainly for medical visualization and not in the domain of Feature-based Modelers [5]. Another related effort generates mid-curves in sketch and then sweeps to form midsurface [1]. This work is in Mix-Dimensional modeling, limited to sweep and does not seem to do feature interactions.

Lee et al. suggested a conversion method from a sheet model to a solid model for the efficient solid modeling of thin-walled plastic or sheet metal parts. This method shows a great potential for degenerate solids in the representation of thin-walled parts. However, because this method adopts non-manifold boundary representation, it is difficult to represent the exact adjacency relations between topological entities in a sheet model and to describe a mixture of wire and sheet objects that appear in the intermediate steps of sheet modeling operations. In order to overcome these problems, Lee et al. [6] introduced a non-manifold boundary representation as a topological framework and proposed a sheet thickening algorithm by presenting variations to a general non-manifold offset algorithm that is based on the mathematical definition of offsets. In addition, to facilitate sheet-modeling operations, they provided a set of generalized Euler operators for non-manifold models as well as sheet modeling capabilities including adding, bending, and punching functions with two dimensional curve editors. However, in these algorithms, all of the holes that lay on thickness faces cannot be removed automatically and topological irregularity of an offset face caused by self-intersection is not yet considered [6].

Thus research so far does not deal with the major problems of midsurface, that of connectivity and simplification. Gaps and extraneous features in midsurface render it useless for meshing operation. Proposed research is planning for improved and robust generation and connectivity of midsurface [4].

PROPOSAL

In the proposed approach, midsurface is generated at each feature operation level which has known face pairs, known boolean operands, so it's more deterministic to compute extension and then trim individual Midsurface patches.

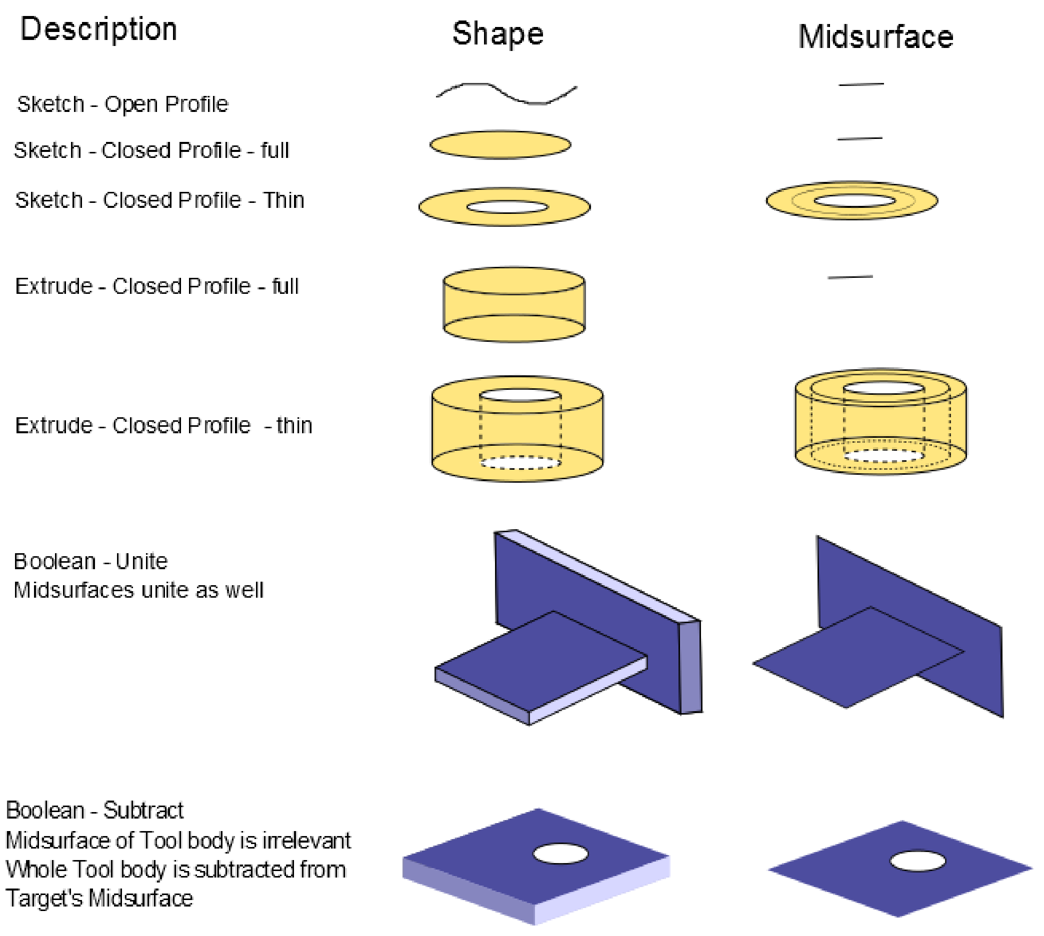

Figure 2: Feature-wise Midsurface

At each feature step, shapes are relatively simple than final shape, thus creation of mid-surfaces at each stage is far simpler (Figure 2). After development of boolean of the non-manifold shapes this method can build well connected, isomorphic mid-surfaces better than the extraction way. Making midsurface as the core data model will significantly improve connectivity and ensure more accurate analysis result. The main crux is that understanding of the sub-shapes/face-pairs and their interactions is far more in-deterministic problem in case of final-body/shape'. Even in simple shapes like 'T', 'K' one needs to formulate rules for grouping face-pairs so that common connection/junction gets created. In a more complex part, situation becomes more difficult whereas if you start creating midsurface as part is being built, at-least one operand in the boolean, called tool body, typically can be deterministic (not simpler). There as the interaction and the boolean type, is known they can be leveraged to arrive at well-connected midsurface. Also, procedure of creating midsurface in existing MA approach and in the newly proposed approach would be different. In case of, say, simple plate, in the existing approach it would guess face pairs, get their surface geometry /sample points and create/fit average/offset surface between the paired faces. In the newly proposed approach, this would correspond to an Extrude feature. It would have, say, elongated rectangle as a sketch-profile which then gets extruded by some distance in the normal direction. Here the mid-curve (a line) corresponding to the midsurface is created in the sketch profile itself. This mid-curve will get extruded similarly as that of parent/original profile thus mimicking shape well. This tool body when will get boolean-ed to the base part, it will know the boolean type and the interaction, thus it would do the boolean of midsurface-patches as well. A non-manifold (surface/sheet) modeler will be proposed for the thin wall modeling in which the data-model will have all the information related to the midsurface. The devised data model will be able to switch itself to the corresponding solid model for the purpose of visualization.

CONCLUSION

This paper proposes a new approach of building midsurface using feature information. In this approach midsurface is concurrently built as part gets created (called forward create). Or this approach can also work on feature based model which can be played back. At each feature step, shapes are relatively simple than final shape, thus creation of mid-surfaces at each stage is far simpler. After development of boolean of the non-manifold shapes, this method can build well connected, isomorphic mid-surfaces better than extraction.

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