Title:
Defeaturing Sheet Metal Models using Feature Information

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Introduction:

Complex models prepared in Computer-aided Design (CAD) applications are often simplified before using them in downstream applications like Computer-aided Engineering (CAE), shape matching, fast visualization, multi-resolution for data transfer, process planning, skeleton computation, etc.
An important phase of the simplification, called defeaturing, is the suppressing of small and irrelevant features, with respect to downstream application, while keeping the overall shape intact. The criterion and the methodology for identification of such details/features depends on the applications such as structural/thermal analysis, retaining overall shape, multi-resolution, etc. This paper focuses on the simplification of feature-based CAD models for extracting the overall/simplified shape.
Many existing methods [4] typically resort to syntactic pattern recognition or similar approaches to first recognize the features on the solid body represented by B-rep or mesh and then remove them and heal the gaps. Feature recognition and removal are typically heuristic in nature and are not robust for complex shapes. In Feature-based CAD models, features being readily available and suppressible, the critical challenge remains of correct identification of them, based on the application context. Existing methods which leverage feature information [3] appear to use the complete feature parameters to decide the suppressibility. This gives incorrect selections, as in many cases, some portion of the features are consumed and are not part of the final shape.
Defeaturing in this paper works in two phases. In the first, a newly-proposed classification scheme (say, decorative, size based, etc) is used to determine the suppressible sheet metal features. In the second, a generic method is proposed to decide suppressibility based on size of the remaining (remnant) portions of the features, thus giving more accurate identification.

Main Idea:

Availability of the feature information simplifies the task of model simplification. The model feature tree is traversed and the candidate features for suppression are identified based on certain criteria.
The overall process of defeaturing is broken into the following two passes:

- First-Pass: Identification of sheet metal-specific features.
- Second-Pass: Identification of generic features by the face-cluster method.

The combined method is called **Smarf** (Sheet Metal and Remnant Faces) method. Application specific criteria can also be integrated, additionally, for context-specific detection of suppressible features.

Sheet Metal Features Taxonomy

Sheet metal parts are prevalent in industries such as automotive, aerospace, process, electronics, etc. Several researchers [2, 1] have worked on sheet metal feature taxonomies for various downstream applications. Our work is developing a taxonomy for defeaturing (and will be elaborated in the full paper) of sheet metal models to find an overall/simplified shape.

First pass - Sheet Metal specific

Sheet Metal parts are built using generic solid modeling features as well as some specialized sheet metal features. The following steps identify the sheet metal features as per the proposed taxonomy.

- Initialize Suppress Feature List sl to which the suppressible features will get added. This list is presented to the user for verification and changed, if necessary. At the end of the pass, features from sl are actually suppressed as one cannot suppress them while the traversal is going on.
- From bottom, go upwards till the Unfold features are present and suppress them. Part changes from the flat pattern to the folded/actual shape.
- The model feature tree is traversed and the candidate features for suppression are identified based on the proposed taxonomy.
- Suppress features in sl.
- Regenerate the model.
- Apply validation criteria.

Figure 2 (a) shows the features selected for suppression by this pass.

Second pass: Generic

This pass works on remaining/generic features, as follows:

- Iterate over the final body faces. Features are not iterated in this case because if the parameters are queried from each feature, they return the full dimensions. In many cases, part of the feature is either consumed fully or partially. So, in our approach, the decision to suppress is based only on the relative size of the non-consumed/remnant feature faces (Figure 1).
- For each remnant face, get its owning feature.
- Build clusters of faces based on the owning features.
- Build a table with entries of each cluster (remnant faces having the same feature owner, Figure 1).
- Size of the cluster can be calculated by various methods like *Influence Volume* (obtained as a difference of the volume if the feature is suppressed and then unsuppressed) or union of bounding boxes of remnant faces. Our work uses summation of the area of the remnant faces for comparisons.

Face ID	Size	Owner
f_1, f_4, f_5	0.25	Extrude1
f_6, f_2, f_3, f_7, f_8	0.12	Hole2
f_9, f_{11}	0.25	Extrude15
$f_{10}, f_{12}, f_{15}, f_{14}$	0.54	Hole21

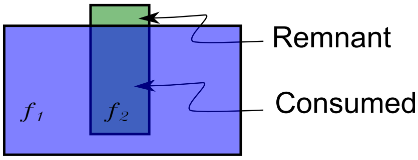

Figure 1: Detection of remnant portion

- Add each cluster-owning feature(s) to sl based on the overall threshold (LoD) value.
- Suppress the qualified features.
- Regenerate the model.
- Apply the validation criteria.

Figure 2 (b) shows the features selected for suppression by this pass.

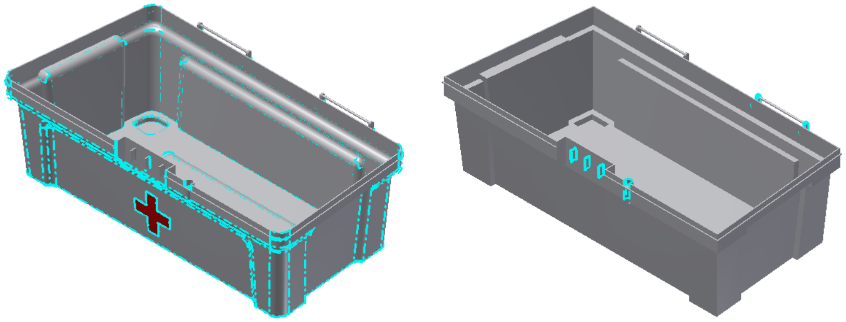

Figure 2: Selection of sheet metal-specific features (a) and based on Remnant Faces (b)

Applications:
Process-planning of sheet metal components need data of the primary/principal features, to decide initial processes such as cutouts, pressings etc., which can be obtained by the defeatured model.
Defeaturing helps not only in simplification but also in computation of midsurface, needed to place shell elements, in structural analysis of the sheet metal components. The proposed method, being feature based, provides bidirectional associativity needed in design iterations between CAD and CAE.
Visualization of complex model can be made faster with the defeatured model.

Conclusions:
Most of the model simplification algorithms are based on the final shape. With the availability of feature information, it has become possible to leverage it for defeaturing. This work proposes two novel algorithms. In the first, each feature is suppressed based on the sheet metal characteristics. In the second, clusters of the remnant faces are formed, and based on the size criterion, qualified cluster features are suppressed.
In the end, comparisons and examples are shown to demonstrate the efficacy of the newly-proposed approach. From the results, it is evident that, even after substantial simplification (with more than 50% reduction in the number of faces) the overall shape/form of the part has been maintained.

References

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