Thesis Review Comments Resolution

Yogesh H. Kulkarni

Thanks to both the reviewers for very detailed and constructive comments. Thanks to my both the advisors for guiding me throughout the process of research and thesis writing. Below are the review comments and their addressal along with my comments.

Reviewer 1: Dr B Ravi, IIT Bombay

Review comments and their addressal

Page	Reviewer's Comment	Changes done	Student's comments
19	'red colour' – Fig. is printed in B & W	Changed to 'dotted line'.	Removing references to colour to allow B&W printing
34	'full features were used for selecting features for removal thereby giving wrong results' – some explanation will help	None.	Explanation is done before, at 2.3.4.4 on page 18. More details in 4.5 as well
41	Detailed approach and methodology **is** presented… should be '… **are** presented'	Changed.	-
61	typicall - typical	Changed	-
63	red colour; in green?	Removed references to colour	Colour references are not a must as annotations were there.
67	This chapter presents approach – **an** approach	Added 'an'	Also, added for starting line of chapter 7
70	Fig. 5.3(1) **show** a – **shows** a …	Changed	-
91	mid**usfr**ace - midsurface	Changed	-
122	Ideally avoid 1-2 (orphan) at the end of a Fig. page	Changed size of Table 6.6	-
187	Incorrect format or journal name missing for [63], [65], [86],[102]…	Added missing info	-

Questions (to be discussed at the time of Defense)

1. What was the computational performance of the proposed approach – time taken (indicate CPU and RAM specs), and what is the improvement over the other approaches (include the time for manual interventions)
    - There are certain inherent advantages of the proposed approach compared to the traditional Brep based approach widely used commercially.
    - The proposed approach uses feature based model, thus avoiding complex face pairing (automated or manual). Defeaturing simplifies the input feature model, thus reducing the number of features to deal with. ABLE reduces the types of features to deal with further. Thus, actual midsurface computation works on highly simplified model and thus must be performance wise efficient.
    - MidAS, the prototype system, has been built as an external application, which needs to call externally exposed VB APIs, whereas commercial applications are built in intrinsic manner with compiled C++ code. Thus, performance timing comparisons between MidAS and other systems does not look on the level playing field. Thus, not

done. Still to get the sense of times needed in MidAS, values for a test case are presented below.

- The proposed Midsurface computation approach is a set of sequential steps with one manual step (cellular decomposition) in between. So, cannot compute the overall total timing, but the individual times as presented here for the Enclosure part (ref Chapter 8, test case 1, with 30 features) on Windows 7 machine with Intel i3 processor, 3GHz with 4GB RAM
    - Detecting Sheet Metal Taxonomy based and dormant features: **1.969112** sec
    - Detecting Remnant Method based features: **5.167295** sec
    - Converting to ABLE features: **30.151724** sec
    - Cellular Decomposition: **Manual**
    - Midsurface generation (includes midcurves, patches, joining): **60.308449** sec

2. What would be results of the proposed approach on a tall cylinder and torus? Has it been tested on injection moulded and die cast parts?
    - Tall solid cylinder is not supposed to create midsurface but skeleton (for beam element). Input expected for this work is a thin-walled CAD model. If cylinder or torus a thin-walled/hollow, like a tube, then the proposed system, MidAS computes the midsurface appropriately.
    - The present work is scoped to sheet metal parts. But just for experiment, variable thickness/draft features found in injection moulded/plastic parts were tried as modelled with generic CAD features and they worked fine.
3. Is CAD model simplification useful for Design for Manufacturability? If so, how?
    - Both, defeaturing and midsurface are useful for Design for Manufacturability
    - Defeaturing results in gross shape which can be used to decide material needed (raw stock), initial/rough/crude machining operations, datum plane selection for fixturing, etc. Typically, the suppressed features are smaller and decorative in nature and can be done with refined manufacturing processes.
    - Midsurface of sheet metal parts can give idea of quantity/dimensions of the raw sheet to be procured, costing. It can also help in more efficient shape search to find parts already present in catalogues.

Concluding remarks by the reviewer (quoted as is)

"In summary, the research work reported in the thesis tackles a very important problem in CAD domain, and presents a comprehensive and elegant solution approach, as well as its implementation and successful testing on industrial parts. The thesis is written in a clear and systematic manner, largely free of errors. The quality and quality (quantity) of research contribution are of the highest quality comparable to the best in the world. I recommend that the thesis be accepted for Ph.D. degree of Savitribai Phule Pune University."

Reviewer 2: Dr Trevor Robinson, Queen's Belfast

Review comments and their addressal

Location	Reviewer's Comment	Changes done	Student's comments
-	One of the difficulties when assessing this thesis is that many of the descriptions refer to colours in the images, but the thesis was supplied to me without colour for	Fig. 4.13 red colour reference removed as it was not a must. Text around Fig. 6.11 was changed to	Removed/Replaced references to colours.

	many images. This made it impossible to assess the appropriateness/relevance of the images.	'different shadings'. Removed from Appendix Defeaturing.	
Sec. 1/2	At the beginning of the thesis (end of Sec. 1 or the start of Sec. 2) I would like a clear statement describing what type of mid-surface this work is aiming to create and why. This would help the reader understand why the author is referring to certain aspects of existing research as problematic. For example it should be stated early one which of the options in Fig 2.2 this work trying to create.	Added statement in Sec. 2.1 "The present research works aims at producing midsurface with G_0 continuity." Added "The midsurface is expected to be…" line in Section 1.3	Clarified expectation about the midsurface earlier in the thesis.
Fig. 2.3	Fig. 2.3 needs more information. There should be a statement that clearly says what contours are show (e.g. stress or displacement), what element types were used, and the key text should be made large enough to read. Both pictures should have the same key values.	Enlarged the figure. Types of elements mentioned in the text around. Corrected the citation.	Standard heatmap scale is used for depicting high stress zones. Red high- Green neutral – Blue low
Fig 2.9	The description around Fig. 2.9 refers to red lines, but there is no colour shown in the image.	Changed to 'dotted line'.	Removing references to colour to allow B&W printing
Sec. 2.4	In Sec. 2.4, there are quite a few mentions of the erroneous faces on the MAT. I think it should be highlighted that these are not an error (i.e. they should be in the IVIAT). The issue is they do not provide the representation that is being sought in this work.	Changed 'erroneous' to 'undesired branches with respect to midsurface expected (Fig. 2.2)'	Modified similar reference in Midcuves Sec. 6.4.6.2
Sec. 2.5	In Sec. 2.5, it would be good to see some reference to what Siemens NX (and perhaps other commercial tools) are able to do. NX has some very good mid-surface identification capabilities which are not referred to.	Access to Inventor and Hypermesh was available.	Access to NX was not available. BTW, Yoonhwan Woo's paper does not consider NX midsurface to be good.
Fig 3.1	The description of Fig 3.1 states the Fig. shows the feature trees, which it does not, This would be a useful addition.	It does not say "shows" but "represented by".	Feature tree picture would clutter here. Elaborate pictures are added in Testing.
Sec. 3.5	Sec. 3.5 refers to some "missing functionality", but it is not clear what this is. This should be clearly stated.	It states the scope, boundaries of the work. It is limited to	Reasoning for scope is given, which comes from limitations of APIs.

		Sheet Metal features.	
Tab.4.1	Tab.4.1 should be bigger as it is not possible to see the missing surfaces. The text refers to a problems column, which is titled differently.	Tittle of the column changed to “Errors in Midsurface”	Pictures just gives overall sense of defeaturing and not detailed error analysis.
Sec. 4.4.2	Sec. 4.4.2 should explain what size is used when idealising a feature. Is it the parameter size in the feature, or is it a measure of the feature?	Face-size (sum of areas of faces) Refer Algorithm 1	More explanation in 4.5.1
Tab.4.2	In Tab.4.2 it is unclear why FaceGroupl is an extrude as it looks like a hole.	It is a blind hole created using Extrude	Extrudes can be negative as well
Fig. 4.9	In Fig. 4.9 it is unclear where the hole features are. A bigger image would help.	Added annotation for Holes and Fillets	-
Sec. 4.7	In Sec. 4.7 it is not clear what the measure of effectiveness is used for. Can its proposed application be clarified? Surely the amount of reduction possible is limited by the shape of the part, and is not always to do with the technique?	Measure of effectiveness is clearly stated by Eq. 4.1. Its application (as mentioned) is to compute Gross Shape.	More number of faces more complex the part is. So, simplification is operation to reduce their numbers
Tab.5.1	In Tab.5.1 it is not clear why seeping an arc along a line results in a cylinder? Surely this is only the case where the arc is a closed circle?	Removed the ‘arc’ mentioned as ‘circle’ is already present.	-
Fig 5.23	Please clarify the point of Fig 5.23. What are the shown primitives the primitives of?	Added ‘to get primitives such as box, cylinder, etc.’	Standard primitives are manifestation of Extrude, Loft.
Tab.5.2	In Tab.5.2 the classification of the Flange and Blend features is not clear. The addition of some more details about how they are provided would be helpful. Perhaps for each an additional column showing the shape of the curve and profile sketch would help.	Zoomed section of the bend for more clarify	Additional sketch and profile column would clutter the table. So not added. ABLE formulae appear adequate explanation.
Fig. 5.25	Fig. 5.25 not clear enough. It needs to include better images with more information. It seems that all of the different features shown in these examples could be represented as extrudes as well as sweeps. It should be made clear why one feature type was preferred to another?	Algorithm 5 explains Extrude representation of Contour Flange shown in Fig. 5.25. Sweep representation is also possible. Depends on which sketch is used.	Preference is given to Extrude compared to sweep as midsurface patch creation is easier

Tab.5.4	For Tab.5.4, it would be nice to see which faces/regions in the model were represented by which features. Can extrudes and sweeps be coloured differently?	Idea was to show equivalence of the parts even after transformation to ABLE	Same example with coloured features is shown in Fig. 8.11
Sec. 6	Sec. 6 refers to deficiencies of existing midsurfacing tools. Some commercial tools do have good capabilities which should be commented on.	Did not have benchmarking access to other CAD packages.	Also, from literature survey it was clear that best output was by Hypermesh and was considered.
Sec. 6.2.2	Sec. 6.2.2 refers to some common problems which occur in some mid-surfacing tools. Please clarify where these problems have been observed (e.g. which tools, under which circumstances,' why do they occur).	Paragraph starting with "Detecting when to …" gives the explanation of "Why"	Earlier, in chapter 2, Fig. 2.20 gives good sense of tool and errors occurring in them.
Fig 6.5 and 6.10	Fig 6.5 and 6.10 need better descriptions. It is not clear where the "intersection" region comes from.	Intersection cell is labelled properly and explained in details in Sec. 6.3.5	At quite a few places intersection/interface cells have been shown and defined.
Sec. 6.3.3 and Fig 6.12	In Sec. 6.3.3 and Fig 6.12 there are some entity labels in the description with 'or " notation. These should be linked back to the Fig. .	These are "O" notation clearly explained as "Overlap" faces.	Same example of "L" has been carried with more explanation at each stage
Sec. 6.3.5	In Sec. 6.3.5, line 5, it should state "nl, n3" (not nl, n2).	Corrected.	-
Sec. 6.4.4	In Sec. 6.4.4, in my opinion (c) is redundant. If there is only one reflex then it will be the closest.	Added just for completeness of possibilities.	Thick cells are ignored.
Sec. 6.4.5	In Sec. 6.4.5, pt 4 some more information on the extension operation is needed. In particular, how is it computed? This is especially interesting where the midlines are not perpendicular.	Extension in this case is to get range vertices. Done by simply interesting two lines (not segment)	-
Sec. 6.6	In Sec. 6.6 more detail should be added to summarise the reinsertion of the negative features. What CAD operations are used to achieve the removal of these features?	Split Face can be used to pierce a surface with a solid tool body. API support is not there but Interactively it can be done.	-
Tab.7.3	Tab.7.3. It is not clear why the hole, which is listed as being 3D in dimension, does not have any face associated with it.	Hole can be 3D, 2D. Corrected 3D to 2D for the picture shown.	-
Tab.7.4 and 7.5	I think Tab.7.4 and 7.5 have become confused. There does not seem to be a Tab.7.5, but	Corrected the wrong table numbering	-

	the citation to be seem to refer to Tab.7.4.		
Tab.7.6	Tab.7.6, I think the model on the 4th row has a genus of 1, and therefore a Euler characteristic of 0.	For 4th case, per Eq 7.14/15, h_m =1, s_m =1 and $r_m = 2r_i = 2$ thus $X_m = 2$ not 0	-
Tab.8.2	In Tab.8.2 it would be good to see how these feature trees correspond to the different regions of the model.	Some prominent features are already named.	Feature subtrees do not represent regions as such. Features can span entire model
Sec. 8.3.8	In Sec. 8.3.8 more should be said about the analysis. For example, this Sec. only shows the model could be meshed and analysed. It would be interesting to see how the analysis of the midsurface model compares to it.	Fig. 8.33 does not show model but the midsurface being meshed and analysed. Caption mentions the same.	-

Some suggestions for improvements to the thesis are:

1. All the work is described very positively. It would be interesting to include a more critical analysis about what the proposed approach is not good at, or to add some suggestions about where it could be improved.

   Following are known limitations of the proposed approach (could be treated as caveats):

   - **Input**: As the proposed approach wanted to leverage the feature information, other CAD data types such as Brep, mesh could not get considered. As it scoped the input features to only generic and sheet metal features, other domains are not considered.
   - **API**: MidAS had to be built as an external application using limited functionality exposed by the CAD APIs. If it has made requisites geometric functions available, including cellular decomposition, MidAS could have been fully automated.
   - Due to improper modelling practices used in the input parts can generate improper parametric constraint propagation. Use of inappropriate threshold values can lead generate invalid output.

2. There is no mention of time to carry out this process. It would be interesting to know how long it takes to process each model.

   Added timings for the sub processes for Case 1 in Chapter 8 (Sections 8.2.2, 8.2.3, 8.2.5). The timings were measured on Windows 7 machine with i3 processor 3 GHz with 4GB RAM. Values are presented in Reviewer 1 comments, question 1.

3. The work in chapter 7, to do with validating the mid-surface created, does not seem to be used for the case studies. This was very interesting work and should be applied more prominently.

   As mentioned in Sec 3.2 (last point) the topological validation is presented as theoretical contribution only. For non-trivial parts it needs a software implementation as manual classification and counting is difficult. Implementation would need low level Brep APIs which are not provided. Thus, topological validation was not used in the test cases.

4. If one of the main applications of this process is for CAE analysis, it should be shown more how the resulting models are more suitable for this than existing analysis processes. The one analysis that is shown does not compare the analysis, or its results, with an unreduced model.

   Comparison of CAE analysis with solid elements and of shell elements on the corresponding midsurface is covered in Sec 1.3 and Sec 2.1. It has established advantages of midsurface. The present research thus focuses on computation of a well-connected midsurface to be given to CAE and not the CAE analysis itself. It aims at providing better/well-connected midsurface only. In chapter 8, comparisons between commercial midsurface output and that by MidAS is shown, demonstrating that MidAS gives less errors and better midsurface.

5. There are many suggested minor amendments at the end of the report (shown in Table above).

   Incorporated.

Concluding remarks by the reviewer (quoted as is)

"In conclusion, I recommend that the thesis be accepted for award of Ph.D. degree of Savitribai Phule Pune University, subject to incorporation of the amendments listed in this report which should be provided during the oral examination."