Latest ANSA developments for IGA modeling

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1 Introduction

During the last years the capabilities of both LS-DYNA and ANSA are in continuous progress in terms of creating and analyzing IGA models, especially in crash and safety discipline. Automotive industry studies the behavior of ever more complex mechanical parts by running simulations using both FEA and IGA within a context where robustness and automation are probably the most important keywords. Pre – processing such parts with Isogeometric Analysis gives more accurate results in terms of displacements but robustness is yet to come. Describing and analyzing the parameters of an IGA simulation singularities, plays an important key role in the latest developments of the ANSA pre – processor, opening the way to study new models of high complexity and build hybrid models.

2 Working with industrial parts

Processing CAD models of complex industrial parts like these we often meet in automotive industry, is still a challenging process. The focus for the moment is in shell analysis, which means that going from a CAD model where thin walled solid structures are being described by their Boundary Representation, to a shell model and end up with an IGA model ready to solve in a robust way is the final target. There are several parameters though in this process that could be the reason for bad results in terms of accuracy or even worst abnormal solver termination.
To overcome the limitation of the fitting algorithm being used to create an IGA patch, the user could follow some strategies while preparing a model for an Isogeometric Analysis. It is important at the same time, for the user, to be able to have an overview of the model in terms of what the solver expects as valid input.

2.1 Subdivide parts

The current approach for complex industrial parts is to subdivide them into simpler ones and come up with as less as possible IGA patches. This subdivision process takes into account the orientation, the curvature and various geometrical features.
In the following pictures the side panel is being divided into four big patches based on the orientation and the geometrical features.

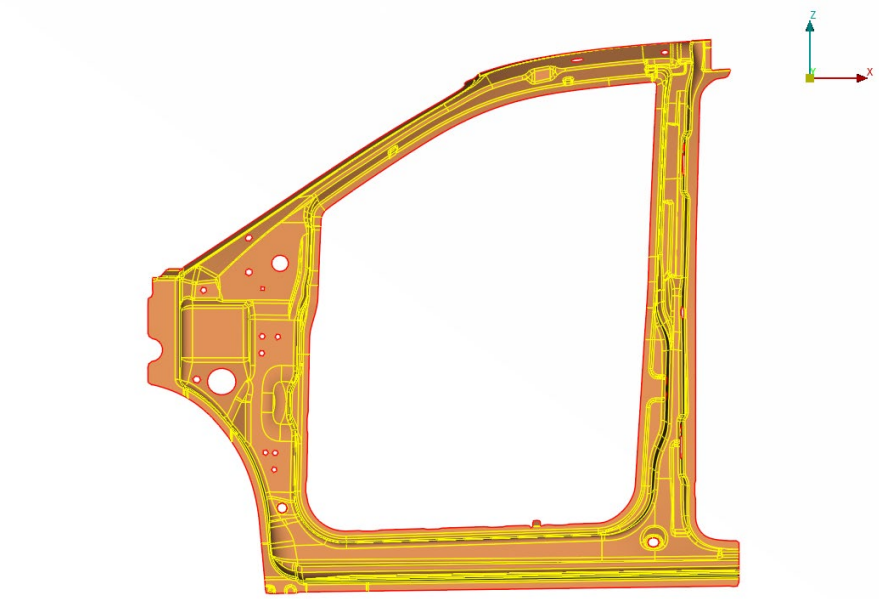

Fig.1: *Side panel*

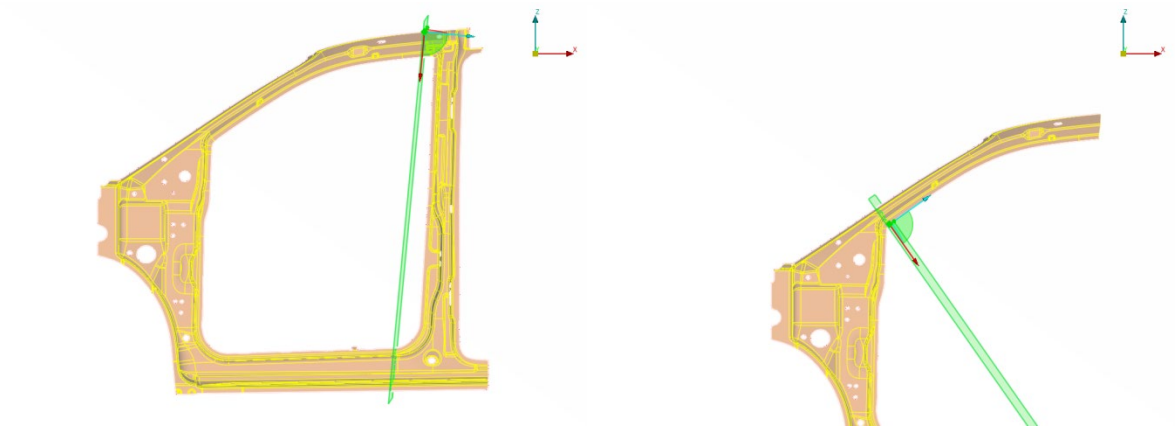

Fig.2: *Subdivide side panel*

In the following example zone cuts should be created in the area where the curvature is very small. These narrow areas should be isolated in separate patches, because they are making things very hard for the fitting algorithm to succeed, meaning that single patch part is not feasible. In addition to that, even if the fitting algorithm was in position to successfully create a valid NURBS surface, this resulting surface would probably have control points with the same coordinates or zero length knot vector spans.

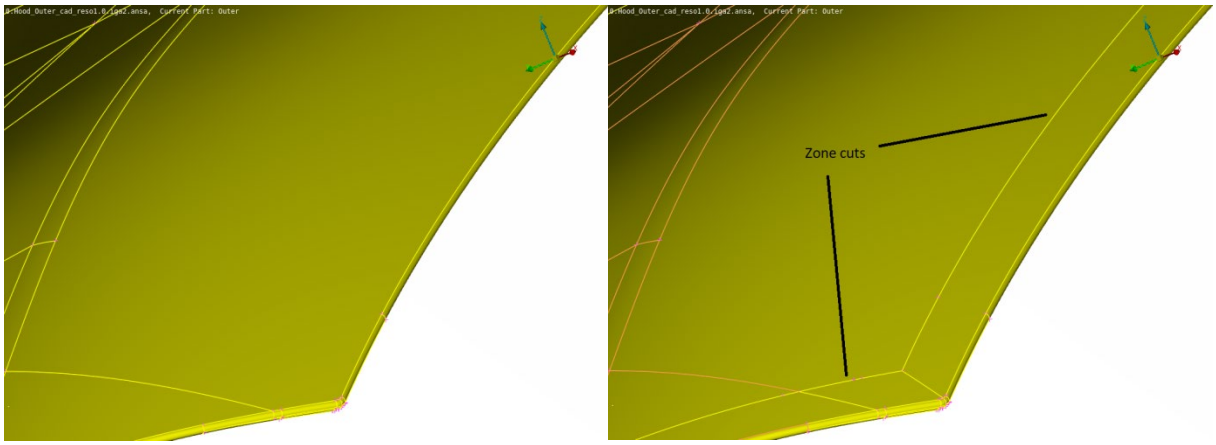

Fig.3: *Apply zone cuts in narrow areas*

2.2 Cross talking

Basis functions support a particular number of knot vector spans of the underlying surface of an IGA patch, which means that in case of small holes or notches or perimeter “wrinkles” in general, forces are actually transferred across void areas without material. Being able to mark areas where this cross talking effect takes place, is one of these important parameters that should be taken into account when building an IGA ready to solve model.
In the following figure we can easily see that a B – Pillar has complex perimeters with a lot of wrinkles and a lot of holes with different size. It is very easy to realize that the number of such parts in industrial applications, is very big and it is not that obvious where the cross taking effect takes place.

Fig.4: *B – pillar with complex perimeters*

A simple notch example indicates a case where there is a “connection” between void areas, because of the underlying basis functions.

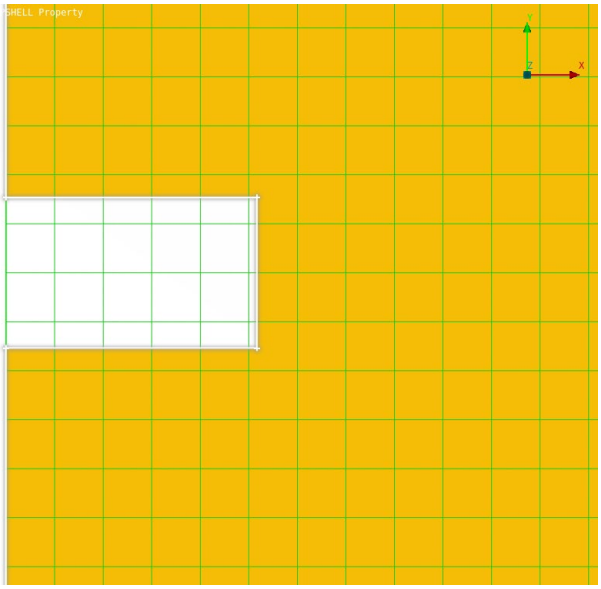

Fig.5: *Notch where cross talking effect*

A solution for this problem is to refine the knot vectors, as we can see in the following picture, but as we can easily understand this is not always feasible and it may decrease the time step.

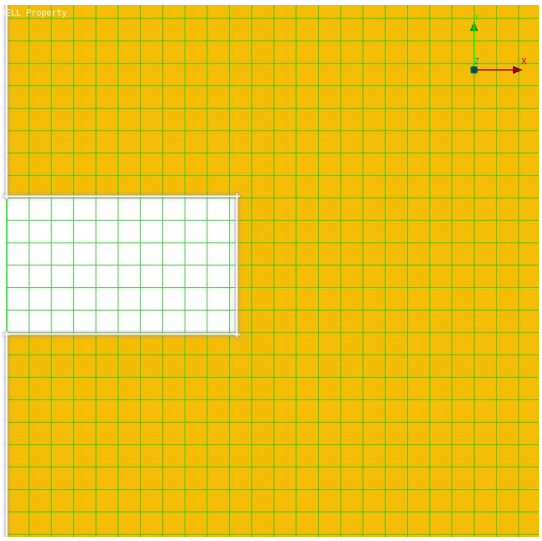

Fig.6: *Refined model*

2.3 Multiple thickness parts

Using of different material or thickness (tailored blanks) is something very common in industrial automotive parts like the B-pillar or the door panel. Processing shell IGA models effectively, requires powerful tools in the direction of being able to define different elements with different thicknesses and or different materials under the same UV domain surface.

2.4 Solids

Mechanical parts are solids and are described by their boundary representations, as it has been already mentioned, thus CAD systems do not provide any physical or geometrical description of the interior. Developing tools towards the direction of defining imersed solids in trivariate NURBS domains, is one of our latest developments in order to take advantage of the LS-Dyna's keywords *IGA_FACE_UVW, *IGA_VOLUME_XYZ and *IGA_SOLID.
Image
An alternative to this, is to work with unstructured BEXT solids, resulting by using body fitted methods and this way we avoid the bottleneck of coming up with trimmed watertight patches. ANSA supports pre – processing solids created using *IGA_3D_BEZIER_XYZ keyword.
Image

3 Auxiliaries

Bringing together all essential auxiliaries in order to result into analysis suitable patches is yet another challenging task. Cross talking is one of them, as it has been already mentioned, but it is not the only one. The more analyses we get, the more tools arise. At this point, apart from the negative Jacobian report which has been already delivered, ANSA pre – processor's developments are focusing on new tools

3.1 Graphics - visualization

ANSA latest developments are focusing on a new high accuracy graphics engine, which will be helpful to locate areas with negative Jacobian determinant, areas with maximum deviation from the original geometry etc. Moreover, fringe plots with knot vector spans or several element quality criteria could be useful in order to warn about potential errors on the solver side.

3.2 Fix topology

On the top of that talking advantage of the ANSA checks mechanism provides a new user experience in terms of automatically locating disconnected IGA patches.

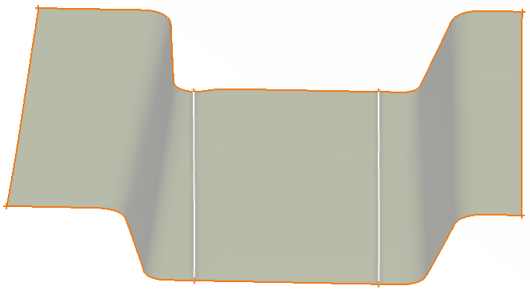

Fig.7: *Adjacent patches*

In the figure above we could see three adjacent faces but it is not easy to realize if they are topologically connected by sharing the same edges as shown below

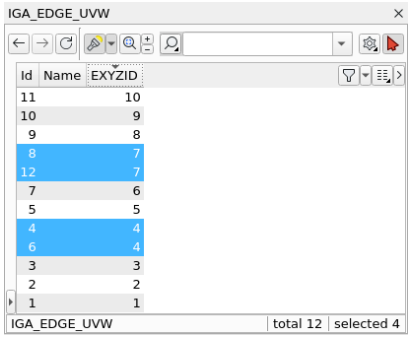

Fig.8: *IGA_EDGE_UVWs sharing IGA_EDGE_XYZs*

ANSA pre – processor will be in position to find out patches that are close to each other but they are not topologically connected and will be in position to automatically fix it.

4 Summary

Isogeometric Analysis has a great potential in studying the mechanical behaviour of shells or solids. Structured or unstructured IGA elements are in the centre of interest both for academia and for software products. LS-Dyna delivers new developments and together with ANSA pre – processor are bringing IGA more close to industrial applications.
However, the complexity in terms of the design and the mechanical properties of modern industrial parts plays an important key role in establishing a seamless process for simulations based on Isogeometric Analysis. Working with these parts and listing the bottlenecks by offering solutions at the same time, is the way ANSA pre – processor's developments are targeting to bring IGA more close to industrial applications.