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BOXER Tutorial:

Automotive

BOXER version 3.10.0

For further information please contact.

BOXERsolutions Ltd.
Suite 1
200 Cambridge Science Park
Milton Road
Cambridge
CB4 0GZ
info@boxersolutions.com
www.boxersolutions.com

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Automotive

In this tutorial, a full car geometry which includes all the underhood and cabin details is prepared for analysis. Working through this example demonstrates one of the major strengths of BOXERmesh - the ability to generate large and complex meshes with just a handful of simple preparatory steps.

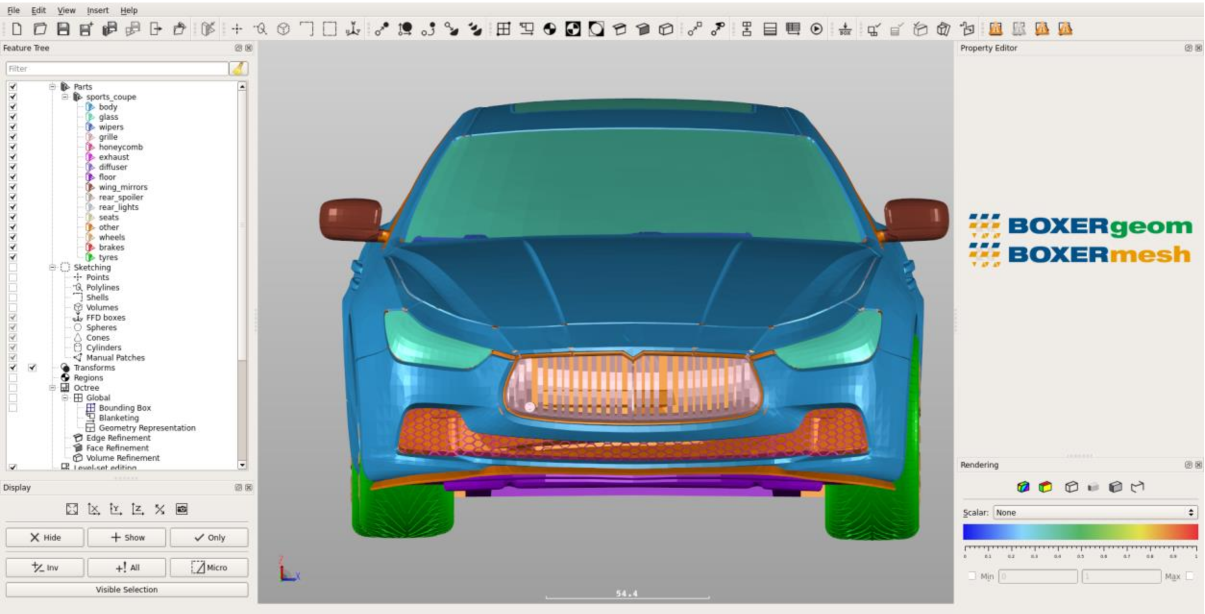
Import the geometry from `sports_coupe.btf` **file**

- `File > Import Part` from the menu bar, OR
- Click the Import Part toolbar button, OR
- Use the keyboard shortcut Ctrl-G

The geometry is imported as a single part containing 27 patches. The patch names will be carried through the meshing process and so appear as named surface patches in the BOXERmesh mesh (`*.box`) file, allowing them to be used in the pre-processor as boundary condition identifiers.

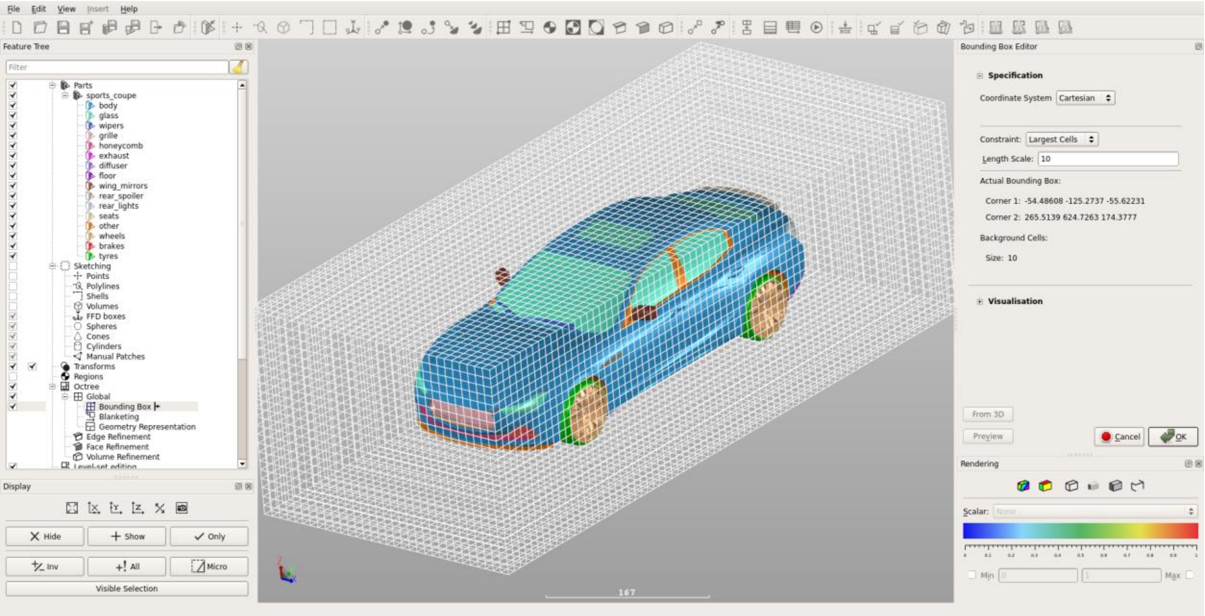
The dimensional units in this case are centimetres.

The default Bounding Box with `Constraint: None` is fitted around the geometry.



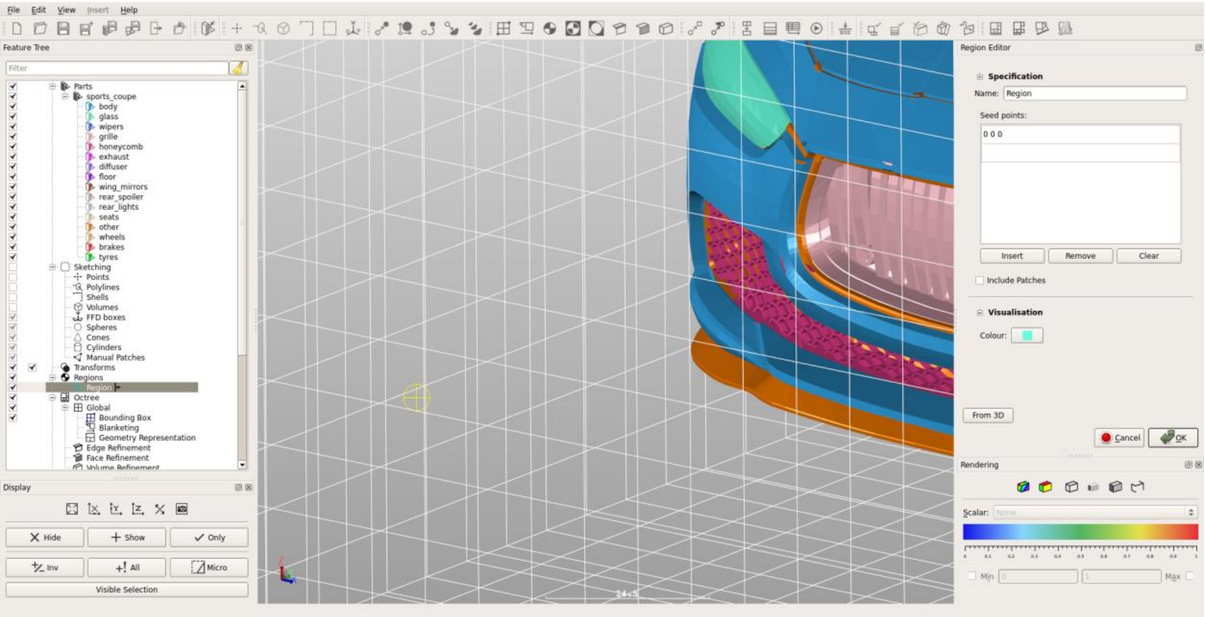
Define the Bounding Box to specify the geometric limits of the mesh

- In the Bounding Box Editor, set the `Coordinate System` to `Cartesian` (the default) and the `Constraint` to `Largest Cells`.
- Set the `Length Scale` to `10`. The `Actual Bounding Box` dimensions adjust to fit an integer number of cells at the specified length scale into a box which is approximately 1.5 times the geometric extent of the geometry in x, y and z.
- Click `OK` to confirm the Bounding Box specification.



Define a Region inside the Bounding Box but outside the geometry envelope

- Set the Region's seed point coordinates as (0.0, 0.0, 0.0).
- Click `OK` to confirm the Region specification. The Region appears via its seed point as a quartered circle in the 3D scene.



Set a 'general' Face Refinement level for all surfaces in the geometry

- Create a Face Refinement specifier for all the geometry patches at octree level 1.

Tip:

Dragging and dropping the part "sports_coupe" transfers all the patches of that part into the Feature Tree subset in the Face Refinement editor. This is a quick way of selecting all the patches in a part. In this case, as we want *all* the geometry, we could instead leave the Feature Tree subset empty; in this case, the default action is to apply whatever mesh refinement is specified, over the whole geometry.

- Click `OK` to confirm the Face Refinement specification.

Set a Face Refinement level for the wheels, brakes and tyres geometry patches

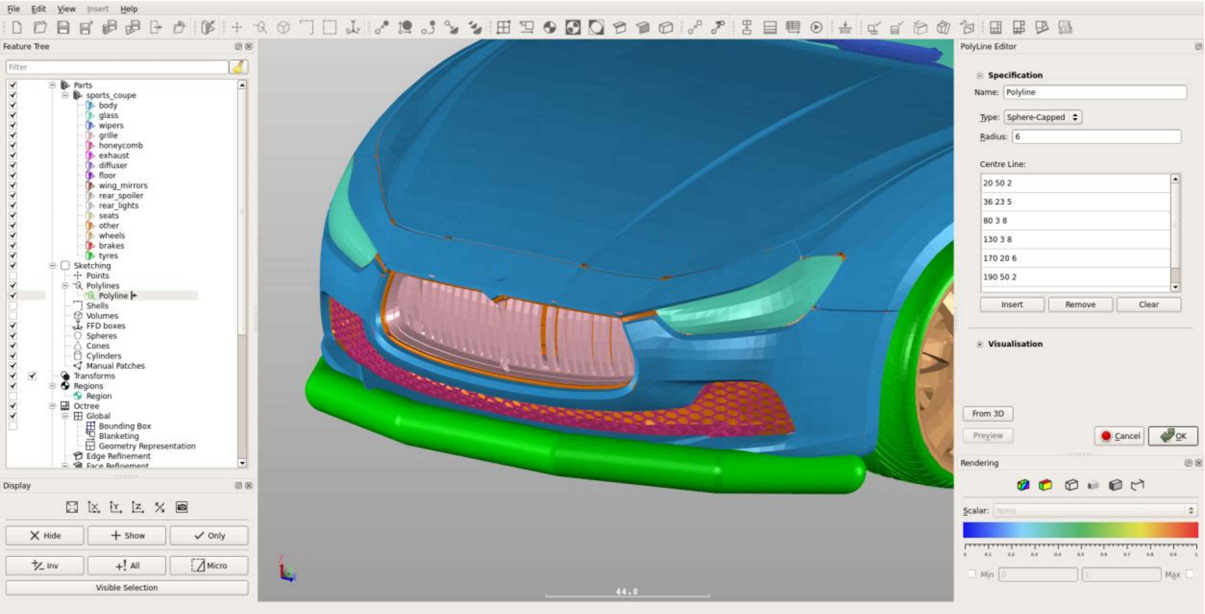
- Create a Face Refinement specifier for the geometry patches “wheels”, “brakes”, “tyres” at octree level 3.
- Click `OK` to confirm the Face Refinement specification.

Create a Polyline to refine the front spoiler

- Create a new Polyline specifier, and clear the default coordinates to leave an empty Centreline list.
- Specify the Polyline by dragging in coordinate data from an external source; in this case, from this documentation page itself. Highlight the coordinates below with the Left mouse button :

```
20    50    2
36    23    5
80    3     8
130   3     8
170   20    6
190   50    2
```

- Hold down the LMB and drag the entire list of coordinates into the empty Centre Line list in the Polyline editor. The coordinates are pasted into the list dialogue.
- Change the `Radius` to 6.0 and the `Type` to `Sphere Capped`.
- Click `OK` to confirm the Polyline specification.
- Create a new Face Refinement specifier, using Polyline `Polyline 1` at octree level 4. The Feature Tree Subset can remain empty – meaning that the refinement is applied to any facet on any patch contained within the polyline envelope



Set Edge Refinement for all geometric features

- Create an Edge Refinement specifier for all the geometry patches. Set the octree level of the refinement at 2.
- Set the `Minimum Angle Deviation` to 40.0 degrees.
- Set the `Maximum Radius of Curvature` to 1.0.
- Select all the patches in the geometry by dragging the part "sports_coupe" from the Feature Tree to the `Feature Tree Subset`, OR by selecting the part "sports_coupe" in the Feature Tree (single LMB click) and then clicking on `Add` in the `Feature Tree Subset`. This is another method for moving items into the `Feature Tree Subset`, although again for *all* patches it can be left blank
- Click `OK` to confirm the Edge Refinement specification.

Note:

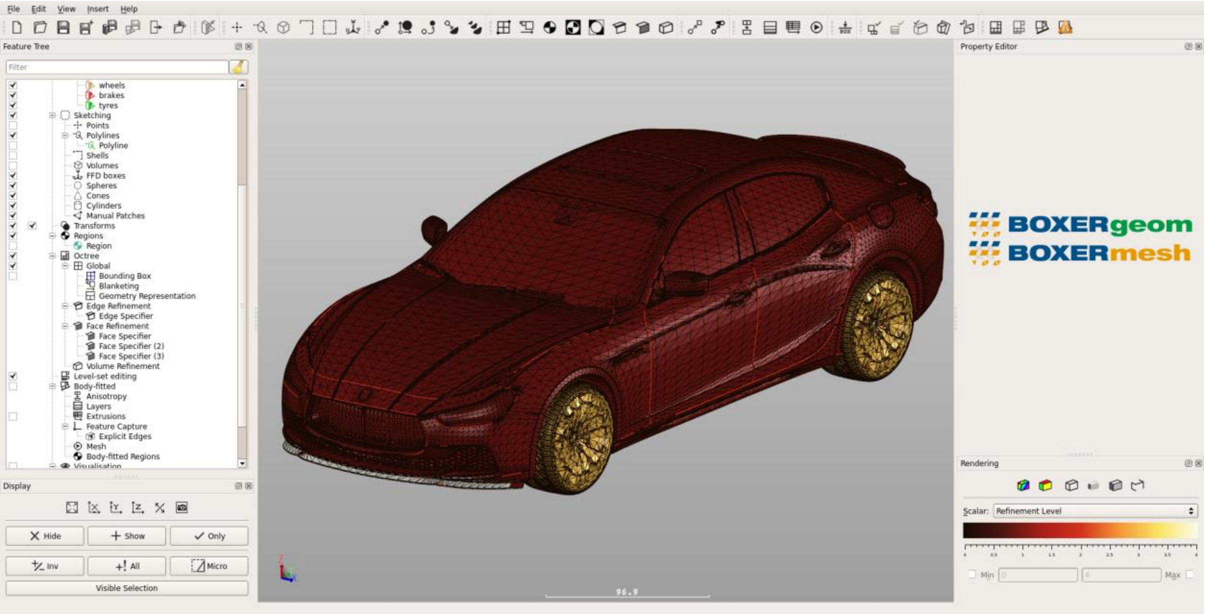
If both Minimum Angle Deviation and Maximum Radius of Curvature are selected as refinement criteria in the same Edge Refinement Specifier, *both* conditions must be met to allow refinement on a particular facet edge. To create an either/or criteria for refinement, two Edge Refinement Specifiers must be specified, one with each criteria.

View the edges that are targets for mesh refinement using Render by Scalar

It is useful to see, prior to computing the full mesh, which edges in the geometry meet the refinement criteria that have been specified.

- Turn off visibility of the Bounding Box and Region.
- Change the display type for the entire geometry to `Faces and Edges` by using the RMB menu on part "car" in the Feature Tree.
- In the Rendering Panel, change the `Scalar` to `Refinement Level`. (If you can't see the Rendering Panel, go `View > Windows > Rendering` from the menu bar.)
- Double-click on the colour-bar directly below the `Scalar` menu picker in the Rendering Panel to bring up the colour map picker, and select the Hot colour map.
- Turn on Render by Scalar using the toolbar button.

- The edges that meet the refinement criteria are highlighted in orange (level 2), the surfaces are rendered in red (level 1) except where they intersect with the polyline (level 4, white) and are specifically set on the wheels, brakes and tyres (level 3, yellow). All remaining edges are in black (level 0).

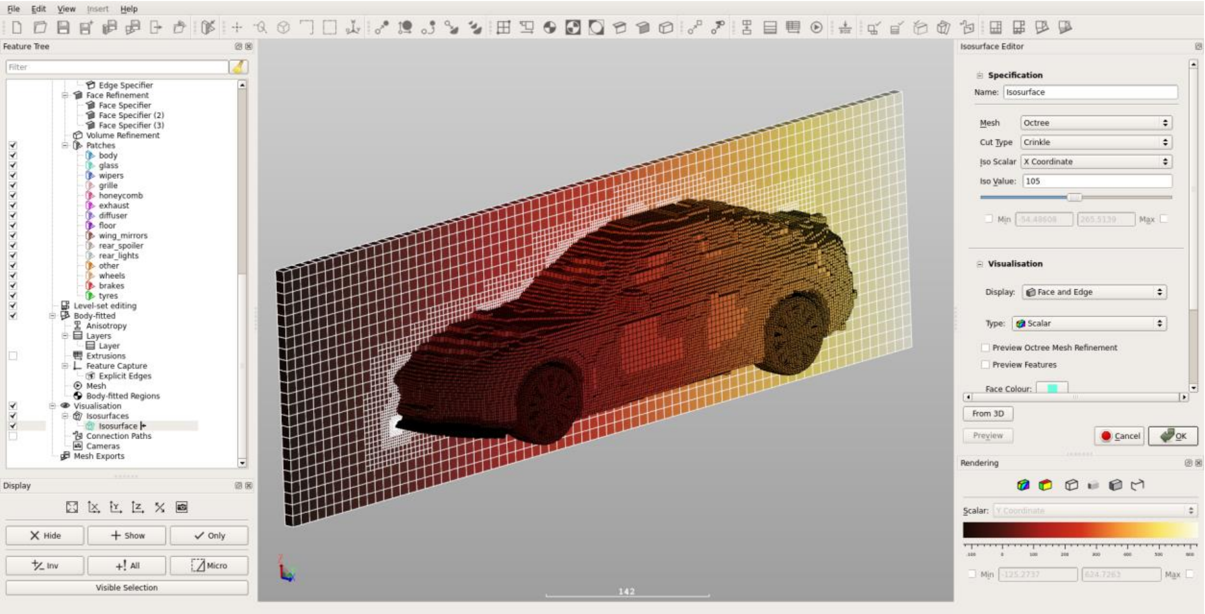


Create a global layer specification

- Create a default Layer Specification for all patches. (`Layer Count` 5, `Expansion Ratio` 1.2, `Initial Relative Step Size` 0.1).
- Click `OK` to confirm the Layer Specification.

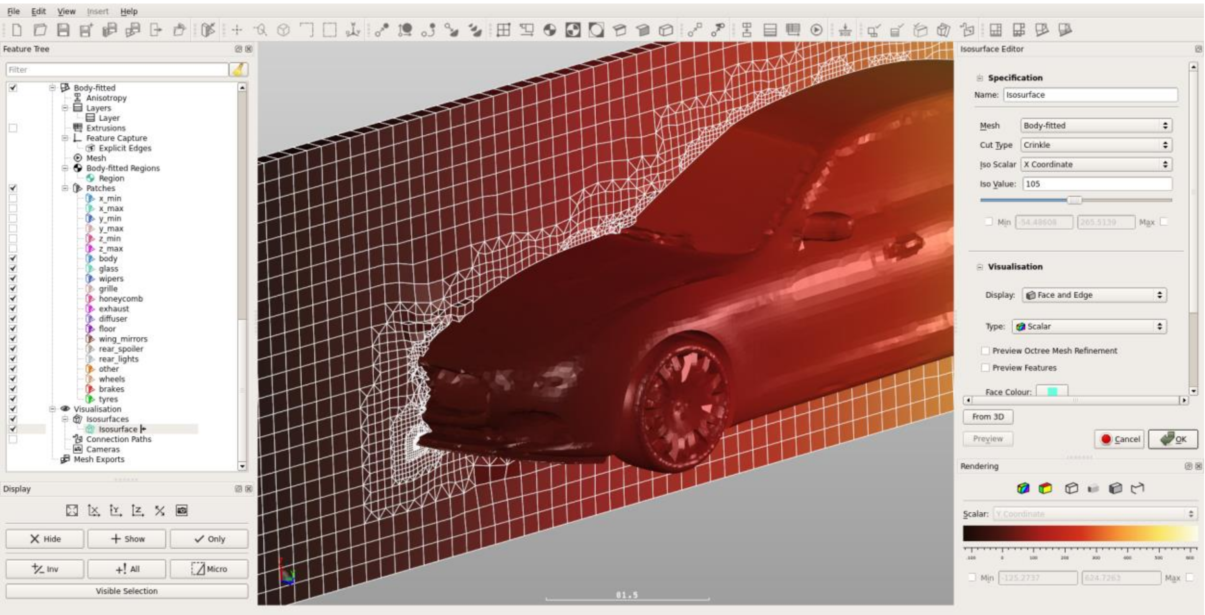
Generate and view the Octree Mesh

- Click on the Generate Octree Mesh button in the toolbar (*the button goes orange to indicate that BOXERmesh is busy*)
- When the octree mesh is complete, the Generate Octree Mesh button goes grey and its action is disabled to indicate that the octree is up-to-date.
- The internal octree patches appear in the scene and also appear as features in the Feature Tree. Turn off the visibility of the parts to see the octree mesh surfaces more clearly. Change the rendering scalar to `Z Coordinate`.
- Create an Isosurface at x=105, to see the octree volume mesh.



Generate and view the Inviscid Mesh

- Click on the Generate Invisicd mesh button in the toolbar (*the button goes orange to indicate that BOXERmesh is busy*)
- When the mesh is complete, the Generate Inviscid mesh button goes grey and its action is disabled to indicate that the inviscid mesh is up-to-date.
- The surface mesh patches appear in the scene and also appear as features in the Feature Tree. To see them clearly, turn off visibility of the octree mesh patches.
- Change the Isosurface to `Mesh:Body-fitted` to see a cut through the inviscid mesh

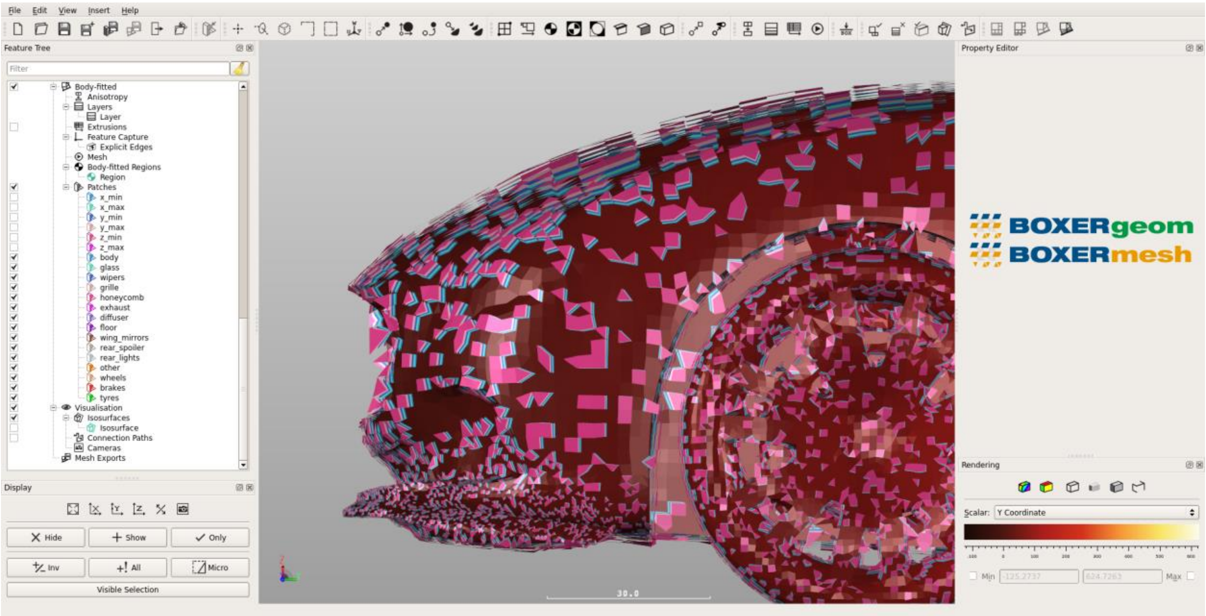


Preview the Layering Specification 

- **Click on the Layer Preview button in the toolbar**

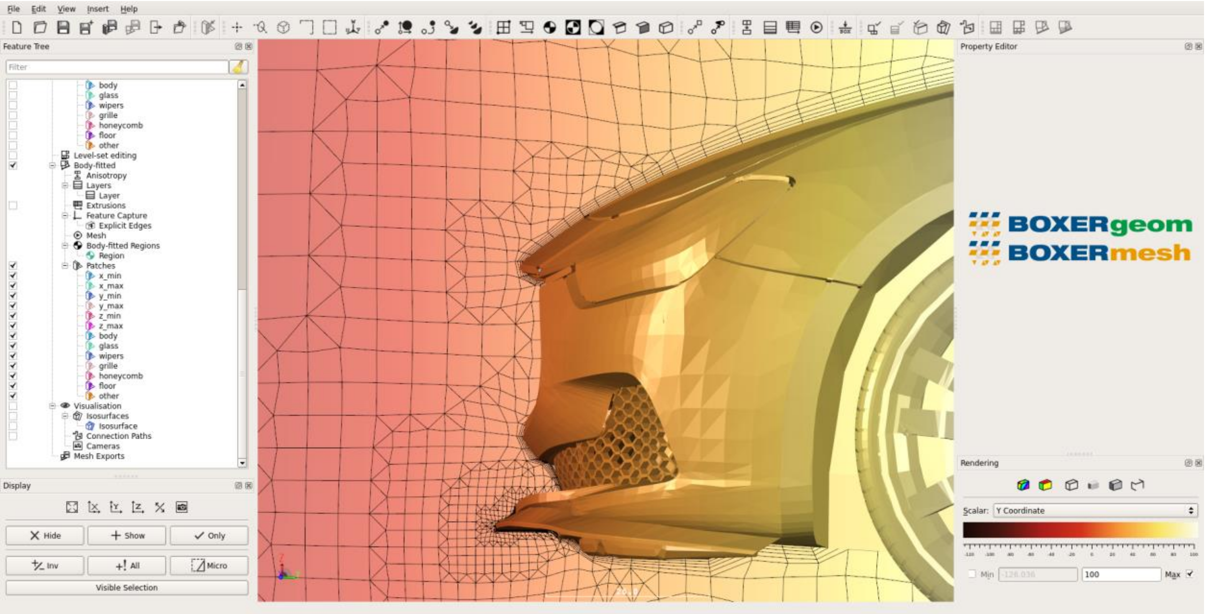
- **Mesh surface facets now display indicators for the viscous mesh structure either using faces or lines**

Change the appearance of the Layer Preview in `Edit > Preferences > GUI Settings`



Generate the Viscous Layered Mesh

- **Click on the Generate Layered mesh button in the toolbar** (*the button goes orange to indicate that BOXERmesh is busy*)
- When the layering is complete, the Generate Layered mesh button goes grey and its action is disabled to indicate that the layered mesh is up-to-date.
- The body-fitted isosurface updates to show the viscous mesh



Save the mesh (`*.box`) on the server filesystem

- Go to `Insert > Mesh Export` and select `BOX` to open the BOX Mesh Export Editor dialog. Alternatively, click the `Create new BOX mesh export specification icon` on the toolbar.
- Leave the name as default `BOX Mesh Export`.
- Click on the disc icon to open a file browser. Navigate to the working directory, enter the filename `car` and check the `Automatically Save with File-Extension (*.box)` tick box. Click `Save`.
- Ensure the `Enabled` tick box is checked.
- Drag the region that contains the mesh (`Region`) from the Feature Tree and drop it in the `Exported Regions Subset` in the BOX Mesh Export Editor.
- Click `OK` to exit.
- Click on the `Save all body-fitted mesh exports` button in the toolbar, or
- `File > Save all mesh exports` from the menu bar.

Save the project file (`*.bxr`) on the client filesystem

- `Save` from the menu bar, OR
- Click on the Save Project icon on the toolbar, OR
- Keyboard shortcut Ctrl-S.
- Click on the `Project` disc icon to open a file browser. Navigate to the working directory, enter a project filename and click `Save`.
- If you wish to save a `.bmf` file then check the `Save Mesh` tick box.
- Click on the `.bmf` disc icon to open a file browser. Navigate to the working directory, enter a `.bmf` filename and check the `Automatically Save with File-Extension (*.bmf)` tick box. Click `Save`.
- Click `OK` to save the project file and `.bmf` file.

Notes on the mesh

The process described above creates a mesh of around 5 million cells. The highest level of octree refinement is 4 (set in the Edge Refinement Specifier) from a length scale of 10.0 (set in the Bounding Box Specifier, this means that the smallest cell edge length will be 0.625 (cm) (=10.0/2^4) which is not short enough to accurately represent the detailed surface geometry. Adding higher levels of octree refinement or reducing the Bounding Box length scale will mean that smaller features can be resolved (with the associated increase in overall cell count).

The illustrations below show the difference in feature resolution between this mesh (left) and a mesh using higher levels of octree sub-division around the tyres and wheels.