Lifted 1.5 Documentation

by

Gary Bollenbach

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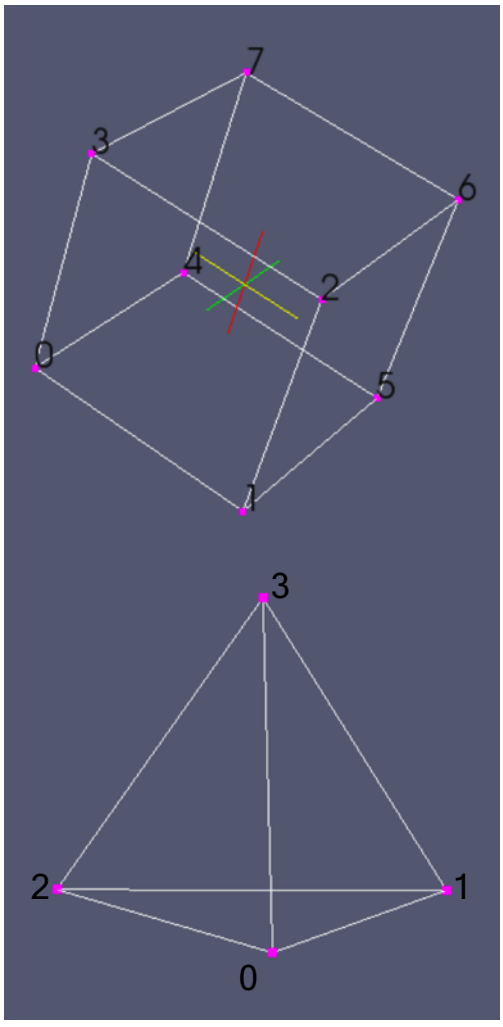
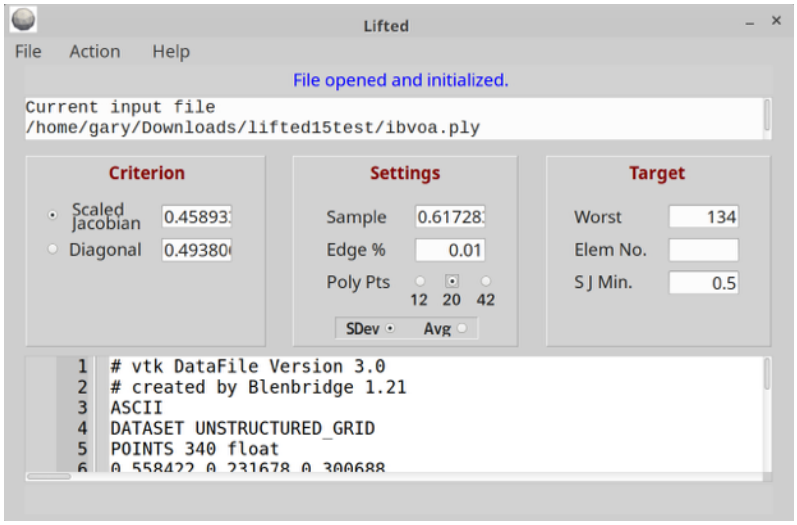
The pic to the right shows the way that Lifted works. The center node is shared by a number of elements, whose edges are seen here as radial lines. A polygon of points, here a twice subdivided ico-sphere consisting of 42 points, is created around the central node. A circuit is made in which a trial move of the central point places it sequentially at each of the ico points, and a quality attribute is evaluated there. The conditions represented by each position are analyzed and saved. Then, if the average quality of the entire group of elements improves when the point is located at the most favorable trial position, that position is retained, and another vertex point (usually the worst case) is considered.

At right is an element with ordinary VTK node winding. Notice that (from the outside) the numbering can go clockwise or counter-clockwise, and that its outside direction reverses for the opposite face.

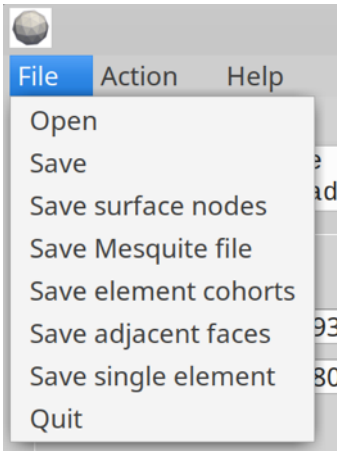
This is not satisfactory for Verdict winding however. The Verdict requirement is for the first face listed to be wound clockwise. In other words, for the cube pictured, the text line 8 0 1 2 3 4 5 6 7 would not be acceptable to Verdict, whereas the line 8 4 5 6 7 0 1 2 3 would be acceptable.

For tetrahedra the Verdict requirement matches VTK. All VTK mesh which is opened by Lifted is rearranged, if necessary, to enforce Verdict requirements.

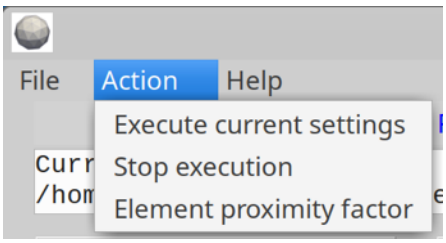




At right is the U/I. On the 'Criterion' panel are located the two Verdict quality standards used by Lifted, along with radiobuttons to show which one controls the current calculations. The 'Settings' panel governs the geometrics of the trial positioning scheme, as well as the method of deciding whether a permanent change in vertex position will be made. (Using the 'SDev' option means that intermediate quality will be ranked and judged according to the standard deviation of the quality of the trial group, whereas with the 'Avg' option the group is evaluated according to average quality change.) The 'Target' panel displays the least conforming element, a text box for single element treatment, and a quality guard factor. Normal termination of the Execute procedure is automatic, based on Sample size. However, a Stop menu item is available if early termination is desired. If saved immediately after selecting the Stop menu item, the saved file will show the quality levels displayed at the time of the stop.



Taking a look at the options in the File menu. The Save option suggests a template name for saving the altered file. The Save_surface_nodes option saves an Ascii text file containing a list of all the surface nodes in the mesh. The Save_Mesquite_file appends a coded Vtk directive identifying which vertices are on the surface, so that these can be immobilized. The Save_element_ cohorts option depends on the specification of a certain element in the 'Elem. no' input field; it then creates a mesh consisting of that element and all neighbors containing any vertex of the specified element. The Save_adjacent_faces option is similar, except that it creates a mesh consisting of all faces which share an edge with the specified element. The Save_single_element option creates a mesh consisting of exactly one element, the one with id number contained in the 'Elem. no' field.

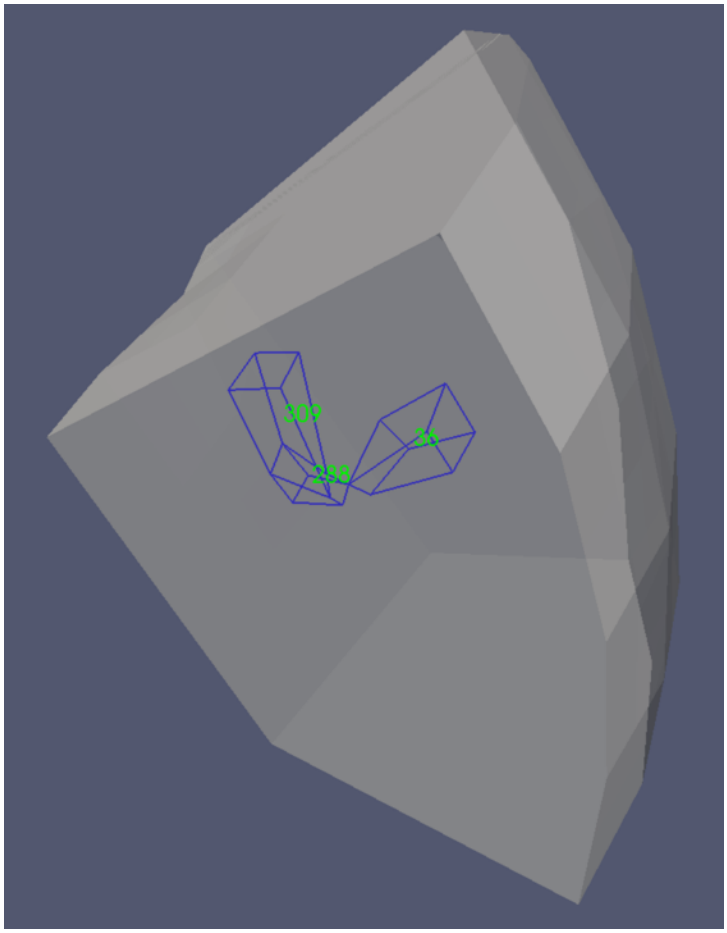


Taking a look at the options in the Actions menu. Execute_current_settings is self-explanatory. The Stop_execution option is explained the paragraph_before_last. The Element_proximity_factor refers to the separation distance between the elements which are considered as being in the local search neighborhood of the selected element (for Save_element_cohorts, for instance). A constant multipled times the sum of the element's long diagonal and that of prospective candidates is compared

with inter-centroid distance and the result used to decide whether the prospective candidate is included in the local inclusion group. The default constant, 0.5, can be changed here to increase the neighborhood size if desired.

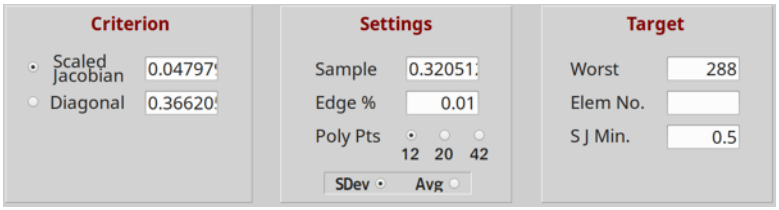
Demo 1

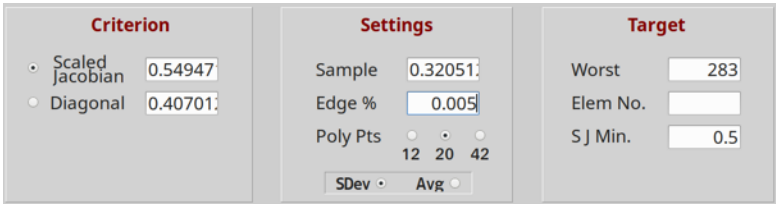
At right is shown the mesh for the first demo. It consists of a chunk of 312 hex elements with a partly rounded exterior. Three of its least regular elements are shown. Because none of the nodes for these elements reside on the mesh surface, Lifted may be able to accomplish a gain in quality. If, say, four nodes of a hex element were located on the surface, Lifted could still operate on the remaining internal nodes.

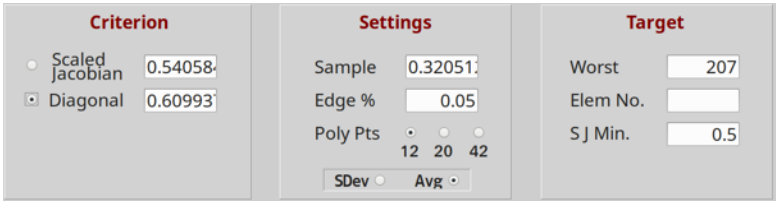


We note that although Lifted can work on both hexahedral and tetrahedral mesh, the elements of the model must all be of the same type. Additionally, elements must be of 1st Order.

In regard to the U/I settings, a Sample box factor of 1.0 means that the number of samples considered is 1.0 times the number of elements in the mesh. The default behavior is to adjust the Sample size internally for a execution process of 99 nodes in succession. This is usually plenty to allow full play of the various parameters prior to lock-up. The Edge % refers to the percent of the minimum edge length of the current node used to define the 'radius' of the test polyhedron. The Poly Pts checkboxes control the number of enclosed test points, making up either a 12-, 20-, or 42-point polyhedron.







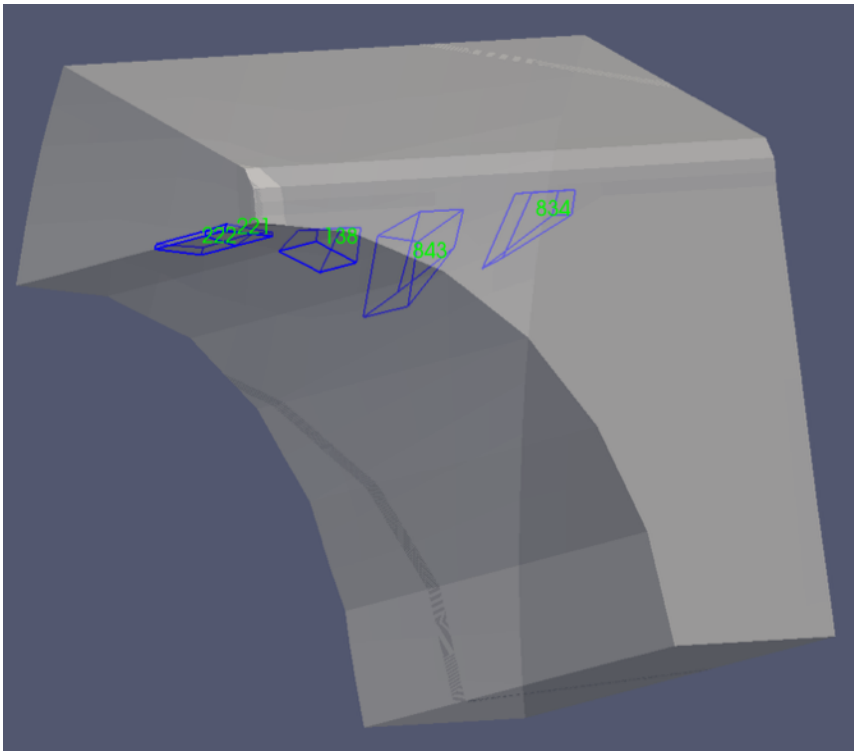
The Verdict standard for Scaled Jacobian of hexes is 0.5, and for Diagonal measure it is 0.65.

Reaching a satisfactory Scaled Jacobian value should suggest a save operation, to establish a reusable base for exploring possible Diagonal settings.

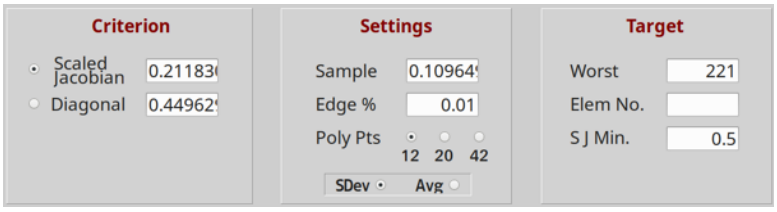
The top table above shows the Scaled Jacobian and Diagonal scores of the demo file on opening. Several runs with the Scaled Jacobian checkbox checked, and Edge % settings between 0.005 and 0.05, middle pic, gives an improved value over the original. Then in the third table we switch checkboxes and play with the Diagonal calculations. The SJ_Min field is left at 0.5, because it is more important to get as good a Diagonal score as possible, than to protect the current Scaled Jacobian. The same range was used for Edge %, and a couple of Avg executions were thrown in, because they helped. The final Scaled Jacobian is good, but the Diagonal is still short of the minimum goal.

Demo 2

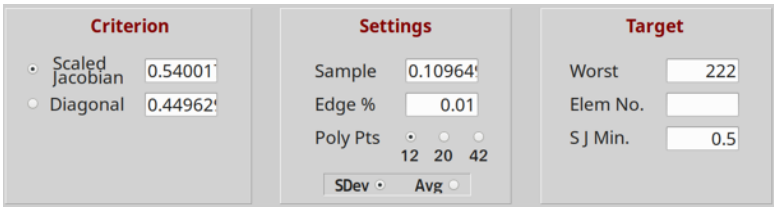
At right is shown the mesh for the second demo. It is a sort of semi-arch of 912 hex elements. Five of its least regular elements are illustrated, and the left three elements shown each have four surface nodes.



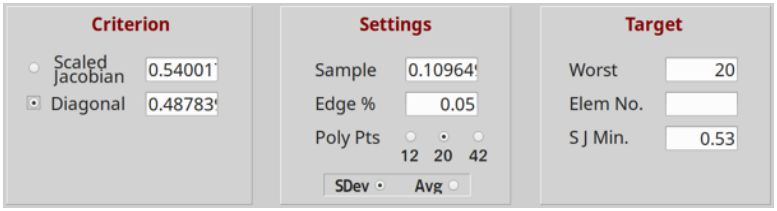
The top pic shows the U/I panels when the file is loaded.



The second panel shows the result of a number of runs with Edge % between 0.005 and 0.5, throwing in a couple of Avg settings when the mesh seemed resistant to further change. The second pic represents quite a few runs altogether, probably about six.

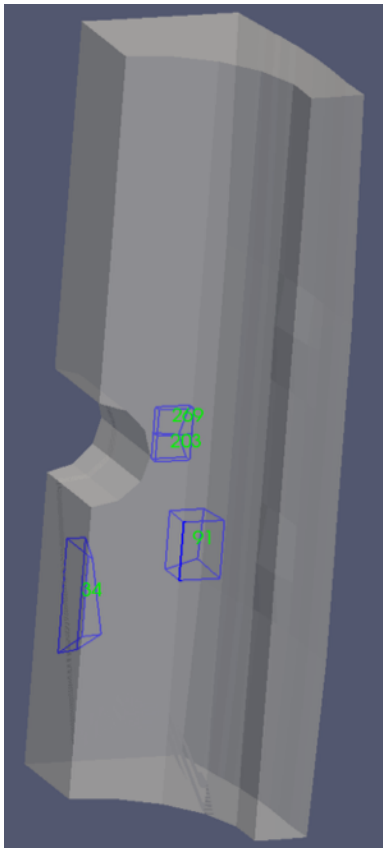


One series of runs with the Diagonal radio button checked informed us that the final value would go no higher than shown in the third pic. Therefore we raised the SJ_Min starting value to protect the Scaled Jacobian which had thus far been achieved.



The SJ Min text block in the Target panel is the minimum Scaled Jacobian which is allowed to appear as the Diagonal is calculated. (It is not fully dependable however, and may require some padding.) Note that Diagonal calculations will not start unless the current Scaled Jacobian is equal to or greater than the current SJ Min.

Demo 3

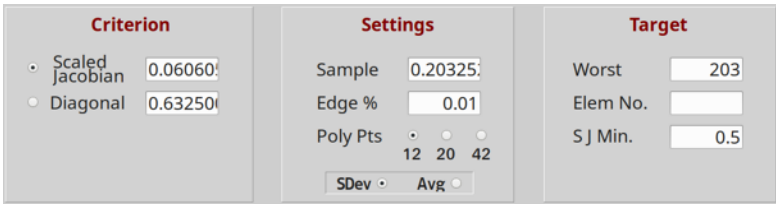


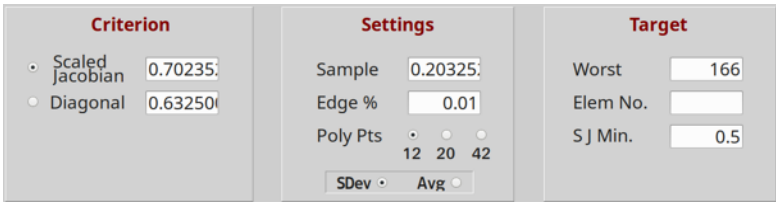
At right is shown the mesh for the third demo. It is a quarter hole with an orthogonal penetration, consisting of of 492 hex elements. Four of its least regular elements are illustrated, and none contain surface nodes.

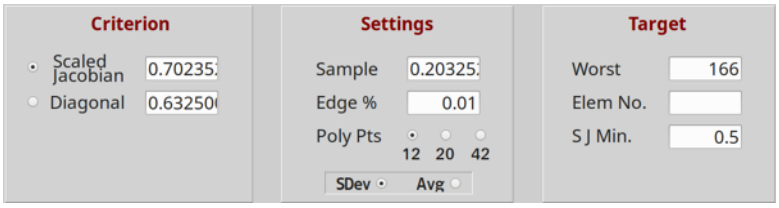
Lifted's testing algorithm is dual in nature. A search path is traveled twice, and in the first trip improvements are sought for nonconforming elements, and the test results stored. Scores are then sorted. At that point the initial conditions are reset, and the number of iterations are conducted which produced the highest score on the first half of the run, thus seizing the optimal value for those settings.

If Lifted encounters a user-entered number in the Elem No edit box, it calculates that element and then stops. This feature is available for special effects, when the preferential sorting of the auto Execute procedure is not desired, or to skip a stuck element and do others. If Lifted encounters a '-1' character in the Elem No box, it reads the quality level existing in the Min SJ edit box as a start point, then tries to improve that level and everything below. In this way the order of processing is reversed, for situations where generalized improvement of the mesh, without concentrating on the worst element, is desired.

The pictures at right show some panels for the third demo. The second one shows that it is easy to obtain a creditable Scaled Jacobian with this mesh. A couple of trials demonstrate a high sensitivity when calculating the Diagonal. Therefore we raise the SJ Min value to protect the Scaled Jacobian, but find it an unnecessary precaution when using the chosen settings.

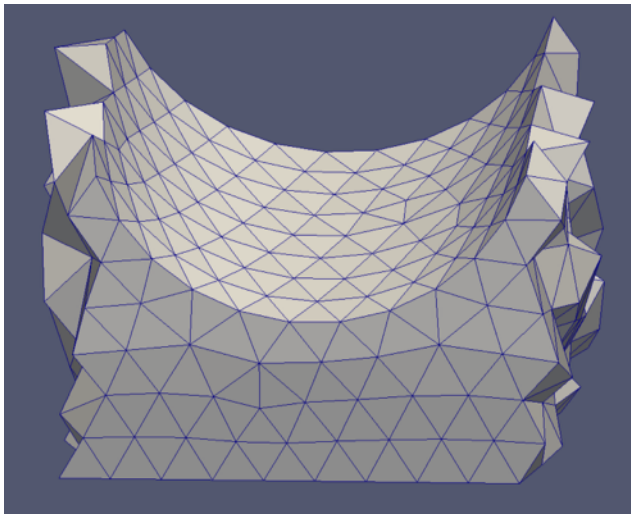


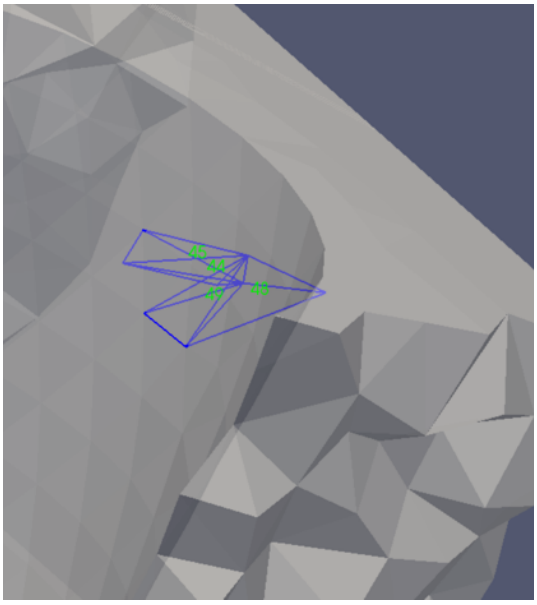




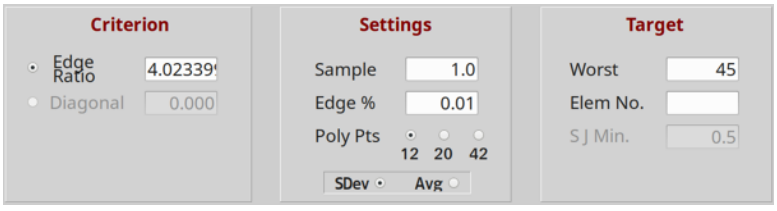
Demo 4

The pictures at right show the mesh for the fourth demo. It is a cutaway of a journal housing, consisting of 1494 tetrahedral elements. Four of the least conforming elements are shown lower right. None of them contain a surface node.

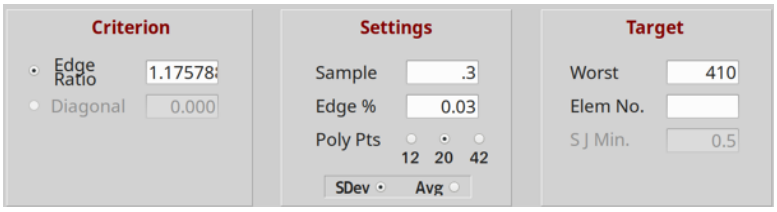




The picture at right shows the Lifted panel upon opening the mesh file. The tetrahedral analysis involves fewer edit boxes than the hex equivalent, and the unused ones are grayed out. The Verdict Edge Ratio attribute is the only one we seek, and the acceptable maximum level is 3.0 according to the standard.

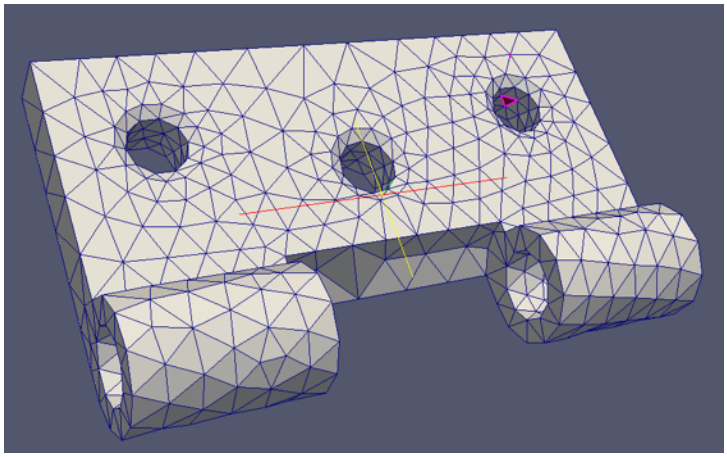


The lower pic shows the edge ratio value achieved after a few straightforward settings.

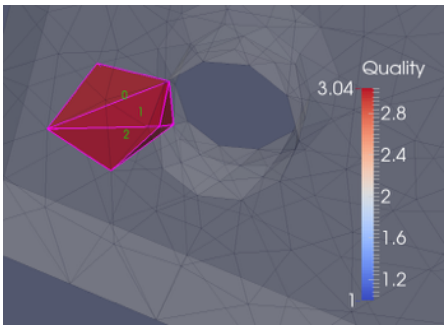


Demo 5

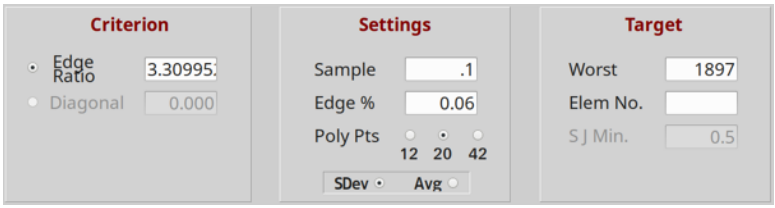
The mesh consists of 2456 tetrahedra. It was meshed with Netgen using a default ‘h’ value. It was saved as a Gmsh file, opened there and and saved as a .vtk file. (See references.)



The three elements with the lowest quality rating are shown. Each of the elements contains surface nodes.



Because the low quality condition is owing to surface node positioning, with which Lifted does not deal, it is obvious that Lifted cannot alter the Edge Ratio quality level. No movement at all can be obtained from the panels.



References:

- Geuzaine, C. and Remacle, J-F. (2017). Gmsh 2.16.0 [Computer software]
- CSC - IT Center for Science. (2016). Elmerfem-CSC 8.2-20170525 [Computer software]
- Kitware, Inc. (2013). Paraview 4.0.1 [Computer software]
- Schöberl, Joachim (2009). Netgen 4.9.11 [Computer software]