

DeskArtes

3Data Expert 16.0

STL and VRML repair examples

Second Edition

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Chapter 1 – Foreword

DeskArtes 3Data Expert software is a general AM tools, covering everything from CAD viewing to STL/VRML data transfer for 3D printing, Additive Manufacturing, and simulation software packages.

This document, *3Data Expert 16.0: STL and VRML repair examples*, describes the use of the latest improvements done for the faceted model repair with 3Data Expert. The use of the commands will be shown through several examples and these commands for faceted model repair (in particular) are covered in the document:

- *Fix Model > Verify Shells* and *Repair Shells* commands for automatic model verify and repair,
- *Fix Model > Edit Triangles* command for manual model editing,
- *Modify Faceted > Boolean* and *Multiple Join* commands for part combination and cutting,
- *Create Geometry > Extrude Surface* to add material on surfaces,
- STL, VRML and ZPR output for 3D printers,
- and several other supporting commands.

The examples contain both STL and VRML models. The techniques shown will apply to any STL, VRML and ZPR model, because the file formats are all used for defining faceted (triangulated) models. The repairing of STL, VRML and ZPR models is identical, the only difference being the additional color and texture handling available for VRML and ZPR models. With 3Data Expert, textures and colors can be added on any faceted model.

Most of the examples will require the use of the 3Data Expert Base module equipped with full set of manipulation (repair, Boolean, extrude, edit triangles, ...) and texturing/coloring commands for triangulated models.

The example models have a variable level of difficulty. The models are selected due to the errors inherent in them. You should normally not meet models with such large numbers of errors if they are designed and outputted correctly from the sending CAD system. The models (a cell phone, a human head and the Maya demo part) are included in the installation package *tutorials/GeomFiles* directory.

All commands and their parameters are explained in detail in the On-line Help of the 3Data Expert. If in doubt, please check the meaning of each parameter from the On-line Help.

If you are using 3Data Expert the first time, you should reserve about two hours to go through all examples. We also recommend that you study the Quick Start Guide and the tutorials before attacking these more problematic models.

The operations given in **boldface** in this document are commands which affect the geometry of the part in question and must be run by the user in the given order to get the results show in this document. Several other commands, like viewing and clipping, are not given in boldface but must be used to be able to generate a correct result. Terms given in *italics* indicate file names, commands, shell names, surface names and parameters for different commands.

The full tutorial set for 3Data Expert contains several documents which cover different aspects of model repair, coloring and print preparation. The tutorials are available in the software distribution package through the *Help > Tutorial Documents* menu. Please check *3Data Expert 16.0: Quick Start Guide* for further information.

The tutorial documents and the geometry files for the tutorial examples are found in the *Tutorials* folder and its sub-folders (*GeomFiles*, *Tutorial 1*, *Tutorial 2*, etc.) in the 3Data Expert (or product in question) installation directory.

Chapter 2 – The cell phone model

The first model to repair is a cellphone model (*tutorials/GeomFiles/cellphone.stl*) You will need the 3Data Expert Base or Lite module to complete this exercise in about 10 minutes. You can also use the Dimensions module until paragraph *Combining the cellphone components* which requires the Boolean commands.

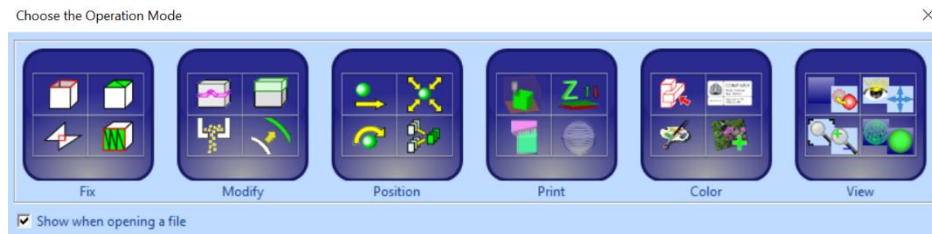
Now

- **input the STL file with *File > Open*** command you can see the model on the graphics area.

For each inputted file the software will ask for the units if not available in the input file.

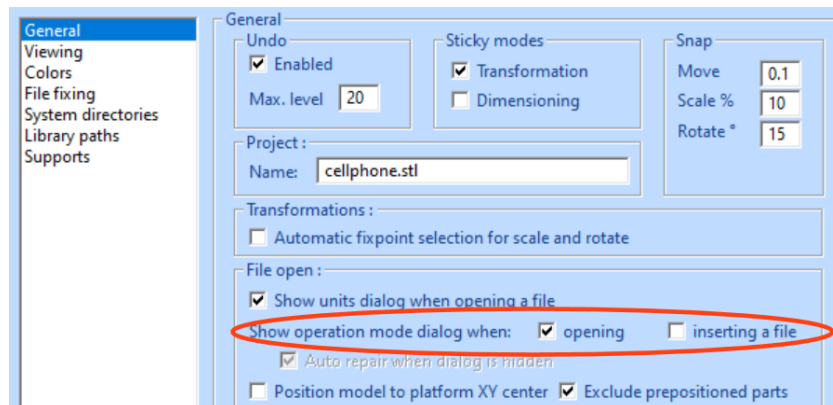
- Select default **millimeter** units and **press OK**

When the units are set the software will ask for the *Operation Mode*:



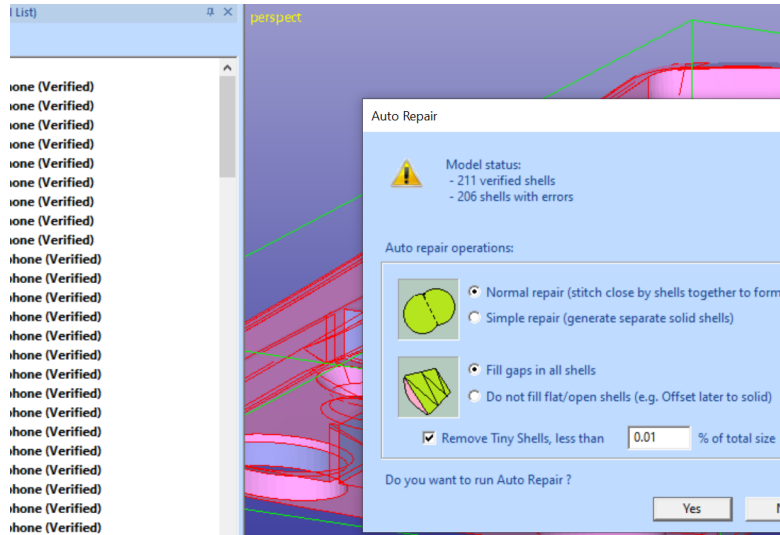
The Operation Mode Window gives a reminder on the possible modification processes you can perform on a faceted model and allows you to select the correct set of tools for any operation. **Note:** if you do not see the Operation Mode window, please make sure the *Show operation mode dialog when: opening* is *On* in the *Edit > Preferences General Tab*.

3Data Expert may also automatically fix the model if Operation Mode window setting is turned *Off* and *Auto repair when dialog is hidden* checkbox is turned on. In that case you can skip the following fix model steps.



The differences in the triangle colors on the display (blue vs. pink) are since the triangle normals are not consistently oriented. The blue color marks the inner side (inverted normal) and pink color marks the outer side (normal) of the triangles.

- Select **Fix Model mode** and let the software run until you will see the following message:



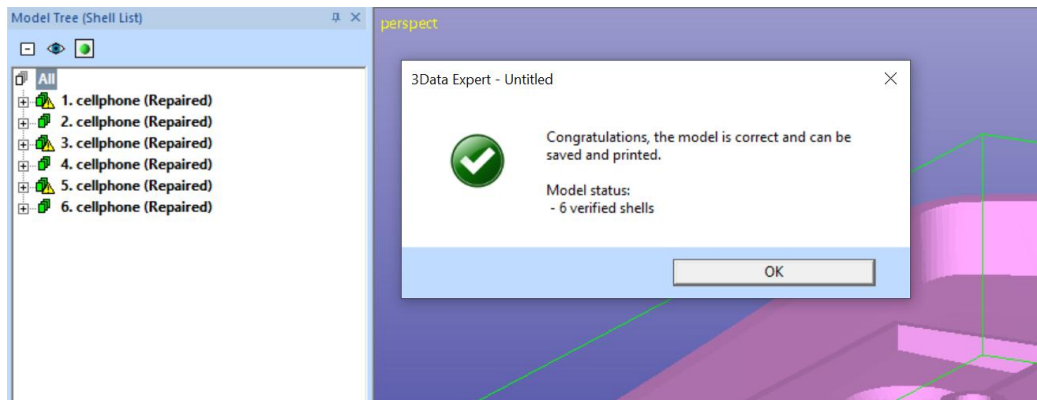
This is the result of the automatic analysis before the Auto Repair (the same result can be achieved through *Fix Model > Verify Shells* command if the Operation Mode Window is not used).

We can see that most of the 210 shells are separate from each other (red gap curves) but obviously should be connected into one single shell. You can zoom and rotate to investigate the model when the Auto Repair dialog is visible.

Auto Repair operation parameters are automatically set for optimal repair result. *Normal repair* will stitch nearby open shells together (more than 70% match with the open edges) and *Fill gaps* will finally fill remaining larger gaps.

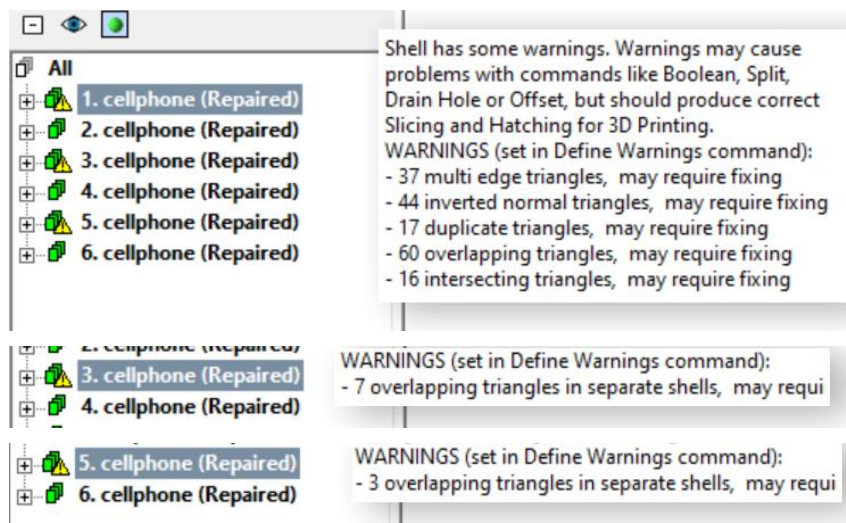
- **Press Yes** to fix automatically as much as possible

After a while you will see the Auto Repair result:



- Press **OK** to close the window.


We have now managed to combine over 200 separate (open surface) components into 6 useful components. Note that three shells have a green-with-warning icon: they contain errors which probably do not cause problems with the 3D printers for which 3Data Expert is targeted. Let's, however, for each of these shells, look at the error descriptions shown in the lower-right corner Help text window:



The first shell is the biggest one and contains most of the errors. The errors can be eliminated with a couple of *Fix Model > Delete Errors* and *Fix Model > Repair Shells* iterations. Even if the model is already printable, in the following we will go through the repair steps, and finally use the Boolean operations to form one final part.

Note: if you have more than 6 shells in the Model Tree, you may delete the small extra shells caused by overlapping surface areas in the model.

Workspace

When the file has been read in, a workspace is automatically loaded, based on the current Print configuration setup. It can be made visible or hidden with the  icon.

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The workspace is not needed for the lessons in this tutorial, so you can keep it hidden.

If the loaded test model does not fit in the workspace, an error message about that is first shown. You can just click **OK** to make it disappear.

Useful Toolbars

Before continuing with the exercises, you may want to turn on the Transform Toolbar,



the Errors Toolbar



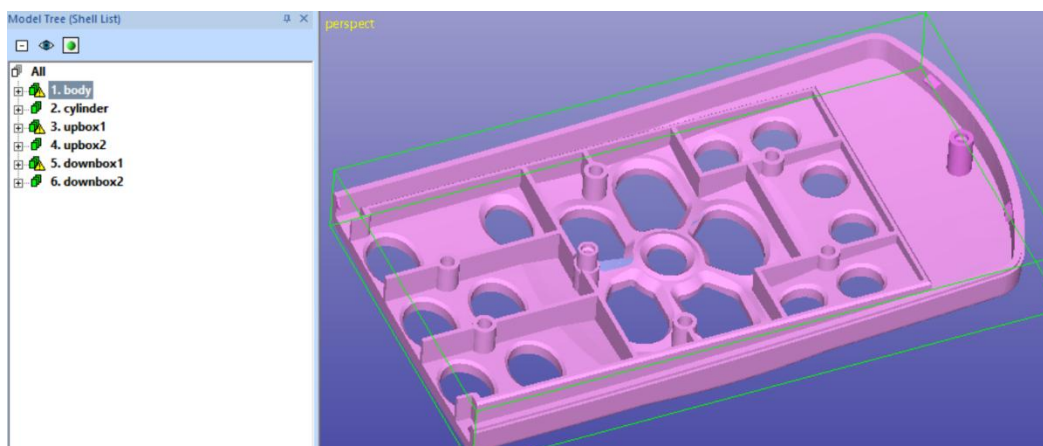
and the Dimensions Toolbar:



They are all turned on via the *View > Toolbars* menu (if not already on), and they contain shortcuts to useful repair commands.

Locating and removing errors in the body

Let's now give a more descriptive name to each component: *body*, *cylinder*, *upbox1*, *upbox2*, *downbox1* and *downbox2*. The first task is to repair the *body* component:



The *body* component has several errors due to the bad quality of the input data.

- **Select the *body* shell**

After selecting the *body* shell in the Model Tree, the *Help Text* window on the right gives a textual description on the errors.

In the image above we can see certain error areas, like a large, inverted area. Most the errors are not clearly visible; these are caused by the other components intersecting the *body*. Also, in the image below we can see areas which have both error triangles and complex gaps caused by duplicate and overlapping surfaces in the original input model (if you removed more duplicate/overlapping surfaces in earlier you may have less errors now).

Help text :

Selected object: shell
1. body

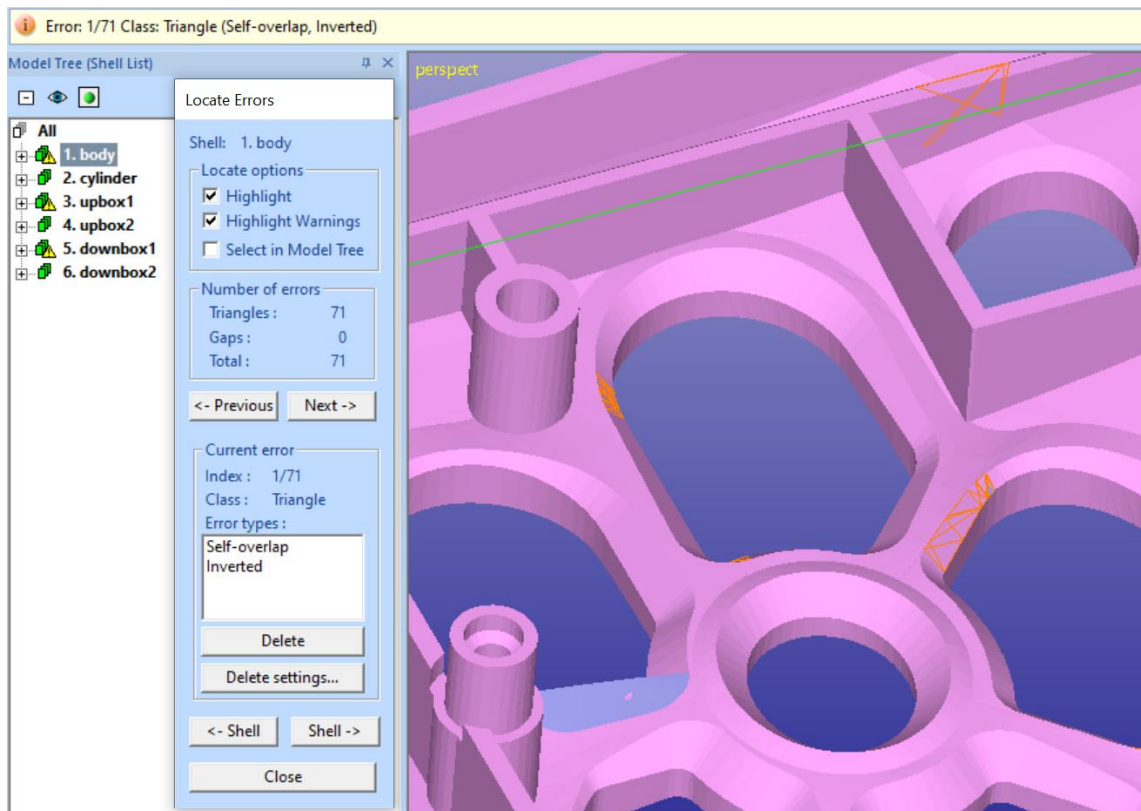
Shell status (error filter: Normal/Part):
- verified, repaired
- shell can be saved and then printed.

Shell has some warnings. Warnings may cause problems with commands like Boolean, Split, Drain Hole or Offset, but should produce correct Slicing and Hatching for 3D Printing.
WARNINGS (set in Define Warnings command):
- 37 multi edge triangles, may require fixing
- 44 inverted normal triangles, may require fixing
- 17 duplicate triangles, may require fixing
- 60 overlapping triangles, may require fixing
- 16 intersecting triangles, may require fixing

- give command **Fix Model > Locate Errors** or press the shortcut



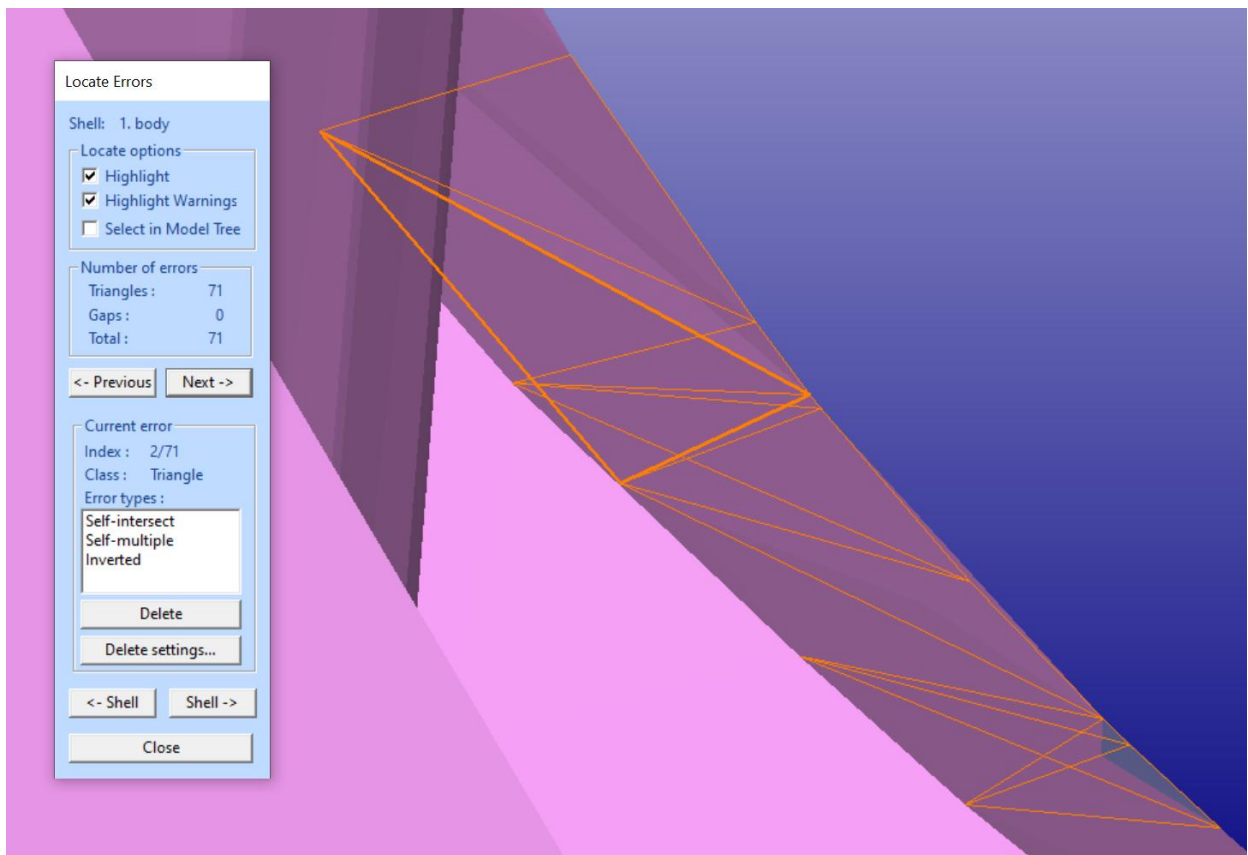
button. You will see the Locate Errors dialog appear. Turn on *Highlight warnings* and error triangles of the *body* shell are highlighted (here we have zoomed to clearly see a couple of errors):



The Locate Errors dialog gives exact information on the currently highlighted error triangle (or gap) in the *Current error* section. Also, the surface containing the error triangle is automatically selected in the Model Tree when the errors are traversed with the *Previous* and *Next* buttons.

We will now use the *Previous* and *Next* buttons to find each area with error triangles and use surface *selection and deletion* as well as *Fix Model > Triangle Edit* to remove or add triangles to enable correct fixing with the next call to *Fix Model > Repair Shells* command. We will not use the *Delete* button available with Locate Errors tool this time, now it is better to use the red error triangles to indicate the error areas for surface selection and deletion.

- **Press Next button** in the dialog and you should see the following error fitted in the middle of the screen:

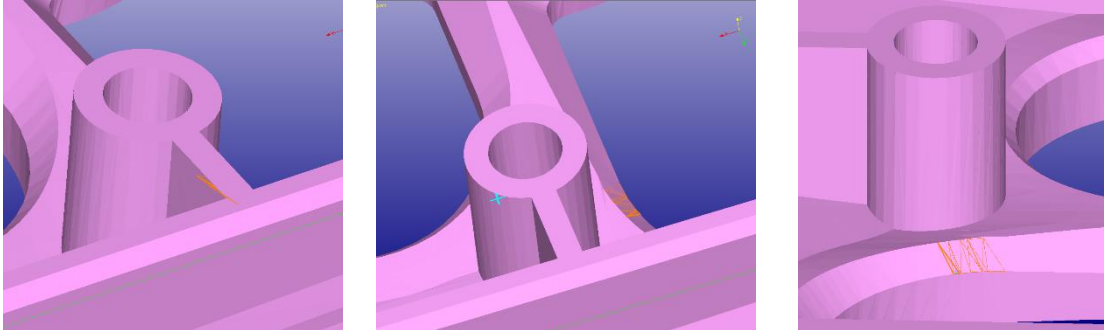


When the model is shown with the viewing direction in the previous window, the error triangles are behind some surfaces. The Locate Errors tool fits the error area to the screen but does not change the viewing direction.

To see the error triangles more clearly, you can

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- 1) zoom out the model (using the mouse wheel or middle mouse button MMB)
- 2) then turn the view to the opposite direction (with RMB rotation around selected point)
- 3) and zoom in again (using the mouse wheel or MMB):

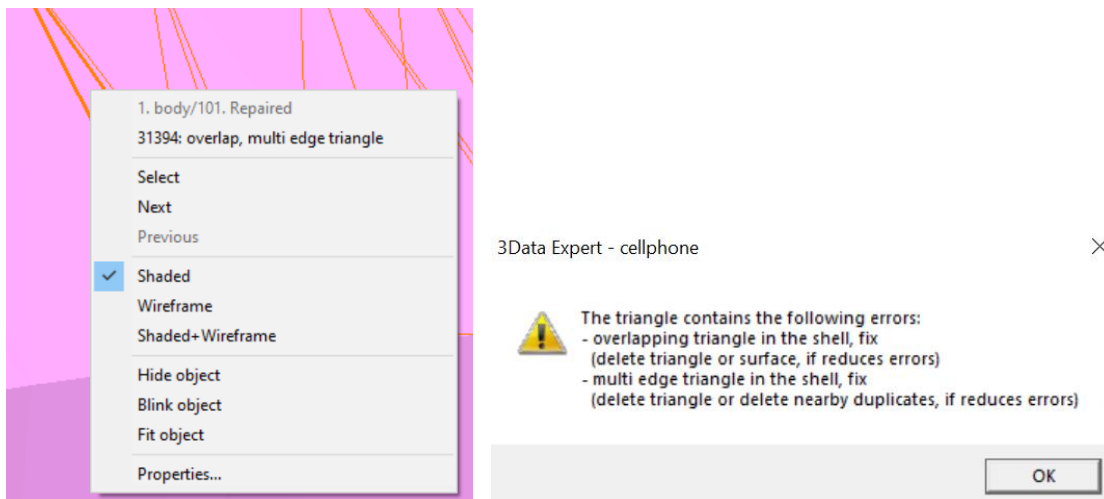


This error area is caused by some overlapping surfaces in the model. You can have a more detailed explanation on each error (red) triangle on the screen:

- **Make sure you have set** Surface selection mode





- **Click on a triangle with the *right mouse button* on the and choose the numbered element** (triangle 31394 in this case):



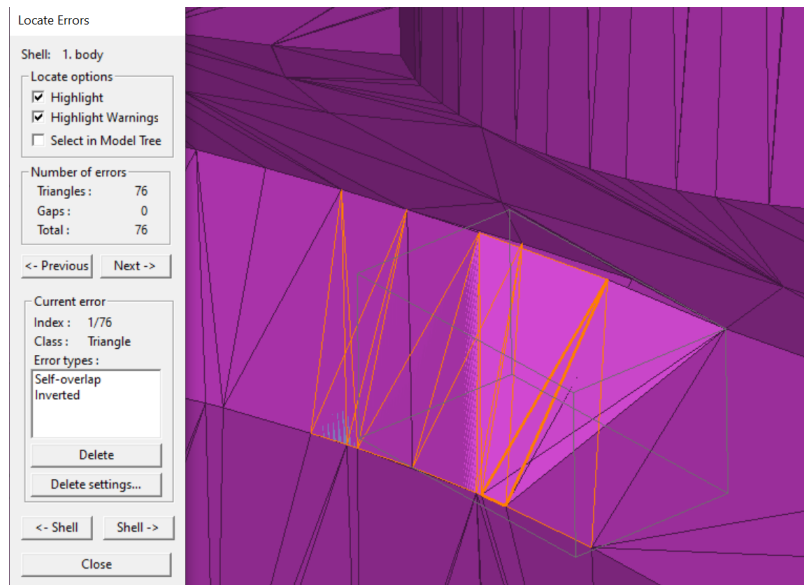
The dialog appearing will give more detailed information on the errors in the clicked triangle. We will follow the first help to remove triangles or surfaces to reduce errors.


Let's now start deleting bad surfaces and triangles in the error area. When we delete small overlapping surfaces, the number of errors diminish and soon we will only have gaps which can be fixed automatically.

You may turn on the shaded+wireframe view mode by pressing the  icon with the *left mouse button (LMB)* and also make sure the selected object bounding box is displayed by clicking  icon.

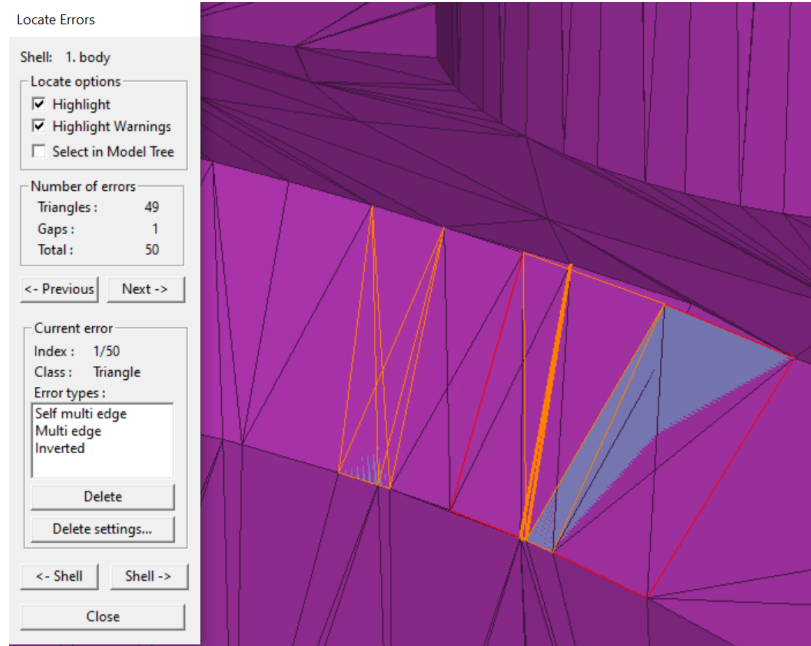
Then

- **click with the LMB (left mouse button)** on the middle of the error area to get an error surface selected:



- Then **give command Edit > Delete** to remove the bad surface or press the Delete shortcut button: 

Then reselect a new surface at the bad area. When removing surfaces **always try to remove the smallest error surfaces at a given error area first**. Also, you should try to first remove surfaces surrounded with red gap curves. You may need to click several times on the same mouse location to figure out how many small surfaces are located in the same area. When you click with the LMB (or the SPACE key) without moving the mouse, small surfaces below the visible surfaces get selected. You will notice that the error status is updated after each deletion:



- Now **repeat selection and delete combination** until all overlapping triangles are removed (again, try to delete the smallest error areas first):

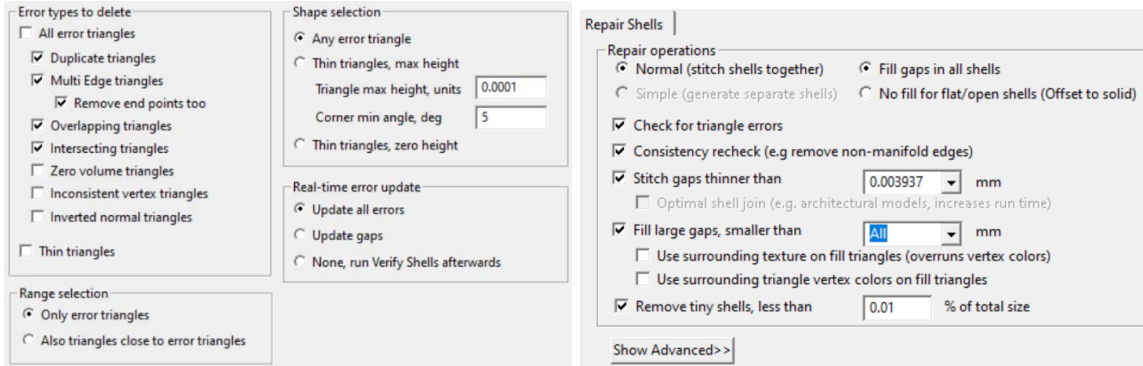
One or several gaps are left in the error area. These gaps will be fixed, even large ones, during the next run to the *Repair Shells* command done later. Now we will go through the rest remaining error areas to perform similar bad overlapping or intersecting surface removal.

You can easily find the next error area by pressing the *Previous* or *Next* buttons in the *Locate errors* dialog. Or you can select the next area visually. Select and remove surfaces until you have removed all bad surfaces in the area.

- You can **close** the *Locate Errors* dialog now.

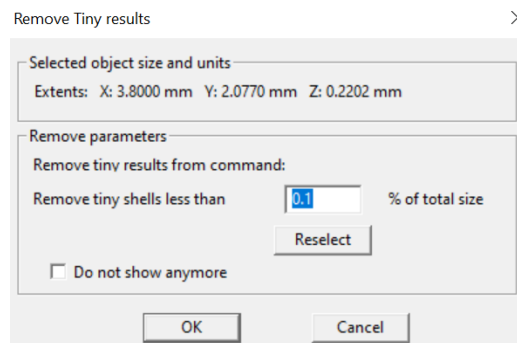
Next, remove rest of the errors in a similar manner. However, **using the *Fix Model > Delete Errors* command, followed with *Fix Model > Repair Shells* is normally much easier to use**; you can repeat the *Delete Errors – Repair Shells* (with default parameter values, usually) commands until you get rid of all errors and warnings (or at least those which may affect your AM process).

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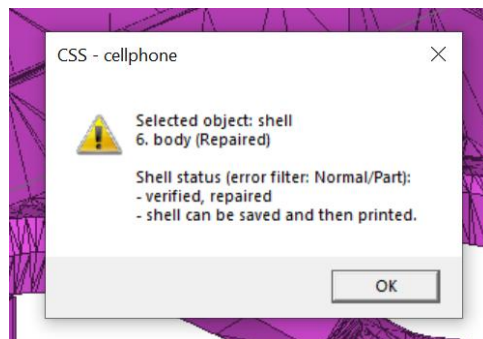
- Now **select the body shell and run the *Fix Model > Repair Shells* command on to fill in the gaps generated during the surface removal.** You can use automatically proposed parameters:
 - **Press OK to start the command.**

The default parameters force detection of tiny shells. If these are found, the removal dialog is shown:



You can safely remove the tiny shells. After the command, if important shells have been removed, you can undo the command and rerun repair without removal of tiny shells or with different parameters.

Finally, we will get a *body* shell without any errors:

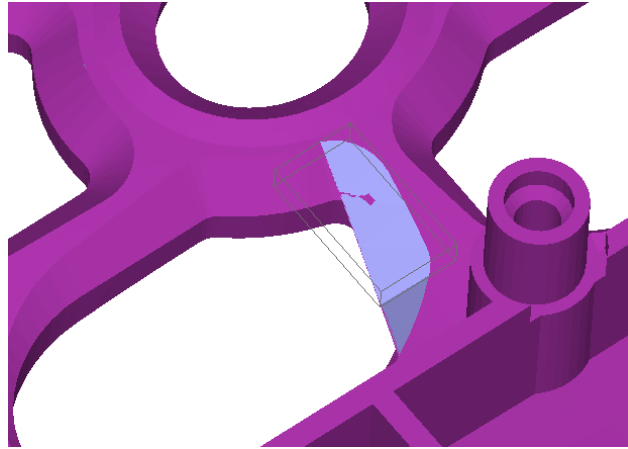


If you encountered problems producing the correct body, you can continue with the file *tutorials/GeomFiles/cellphone-body-repaired.3de* stored in the distribution package.

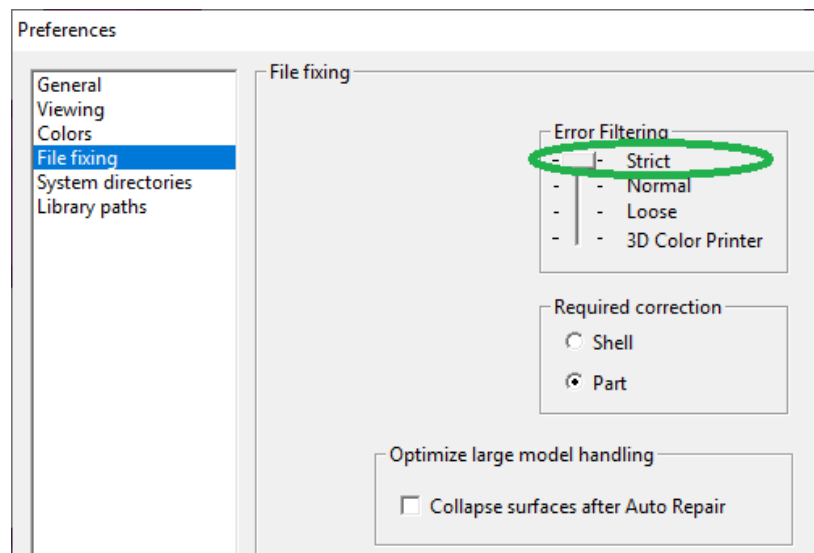
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Note: If you are still left with some errors and seem not to get forward, you may try the *Fix Model > Edit Triangles* command to remove individual triangles from areas with errors. Just start the command, click on triangles with LMB and finally RMB to remove them to make clean gaps for the automatic gap filling with Repair Shells command.

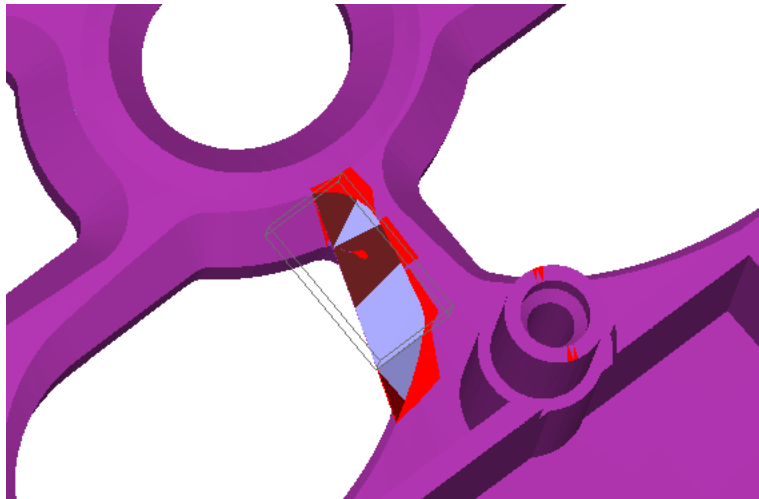
The model will still contain a zero-volume area where two flat surfaces are on top of each other. Depending on the receiving 3D Printing system these areas must be removed or left into the model.



We are currently in the *Normal Error Filtering* mode. If you set on the *Strict* Error Filtering through the *Edit > Preferences > File Fixing* settings, you will see more errors and remove them using similar techniques as above.

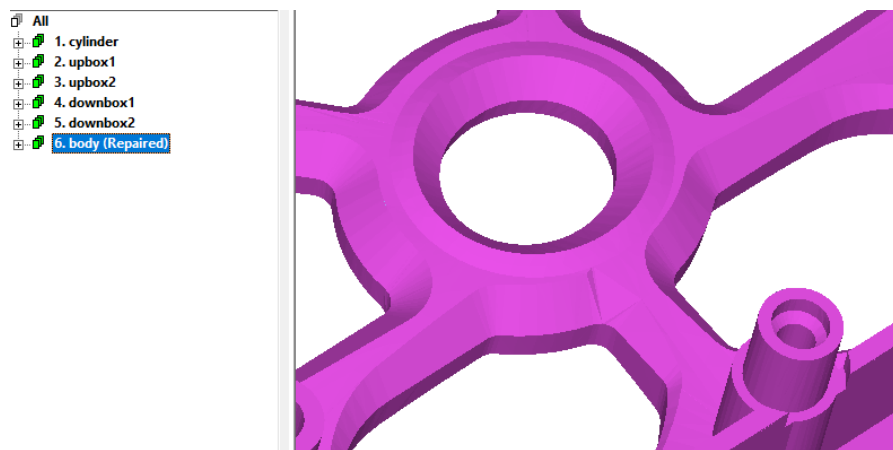


More errors shown with Strict mode:



These steps are left as an exercise to the user:


- **Select and remove** two overlapping surfaces in the displayed area
- **change back to *Normal Error Filtering* mode.**
- **run Repair > Shells** on the *body* shell with default parameters

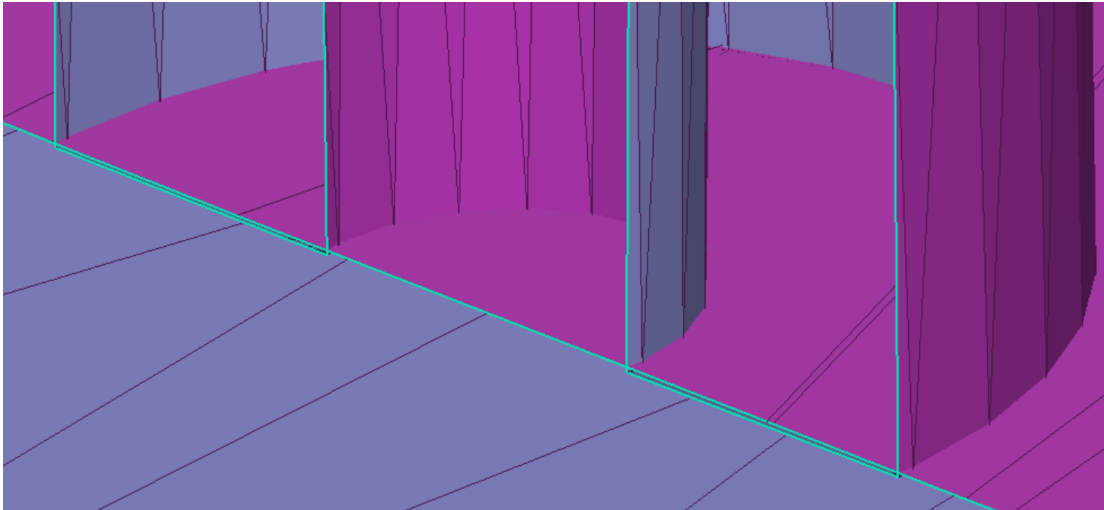


We now have 6 printable shells in the Model Tree. Depending on the receiving 3D Printing process, we may need to connect them into one connected shell.

Combining the cellphone components

The *Modify Faceted > Boolean* command is used for combining the 6 components into one correct STL file.

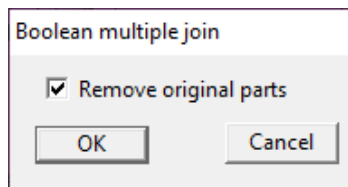
We will first combine the *cylinder* with the *body*. As we can see in the image below (using clipping with the  icon) the two components are slightly intersecting:



We can connect these two shells into one by simply using the *Modify Faceted* > *Multiple Join* or the *Modify Faceted* > *Boolean* command. We will use the *Multiple Join* command.

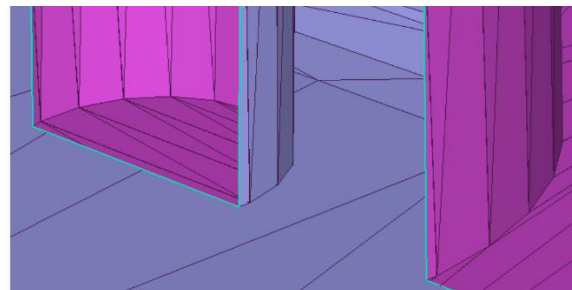
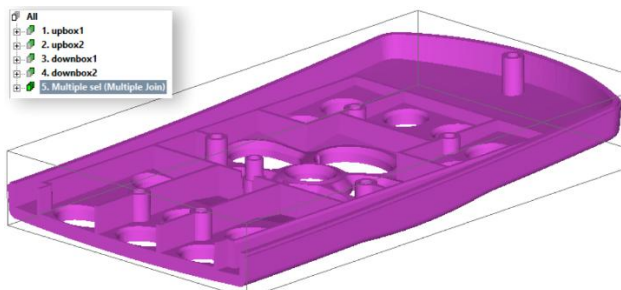
- **Select the *shell 1. body* and *shell 6. cylinder*** as shown in the image above.
- **Give command *Modify Faceted* > *Multiple Join***

Soon you are asked to *Remove original parts*:



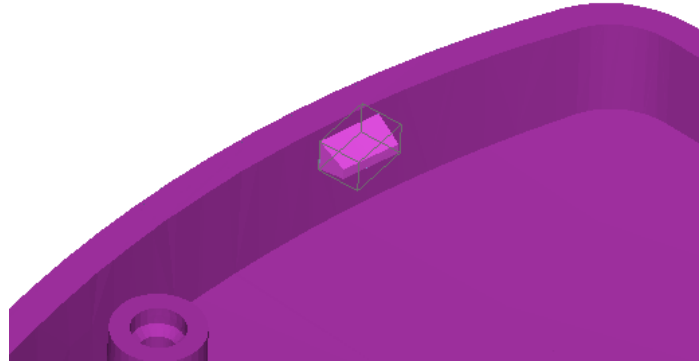
- **Press *Ok*** to *Remove original parts* and to commence the Boolean operation.

Soon the result will appear, the two shells are connected, and the result is stored in a new shell, *Multiple sel (Multiple Join)*:




Now we will connect the fixtures *upbox1* and *upbox2* shells to the *body*. The fixtures are too far from the *body*, so we either need to move them towards the body or we need to generate extra material on the surfaces facing the body. Now we will generate more material on the surfaces. Extra material is added with *Create Geometry > Extrude Surface > from Surface* command.

We will add material on the *upbox1* shell, selected below in the Model Tree:

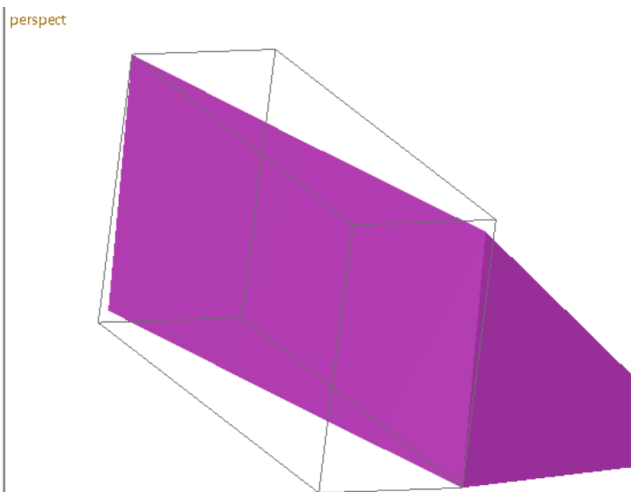
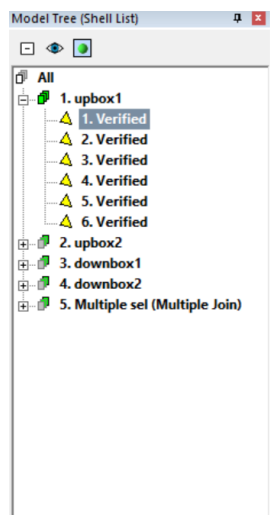


To be able to create a Boolean result, we will add material to the surface which faces the *body* shell.

- **Fit** the shell with LMB +  icon or double-clicking the shell in the Model Tree
- *make sure* you are in the **Surface selection mode**:

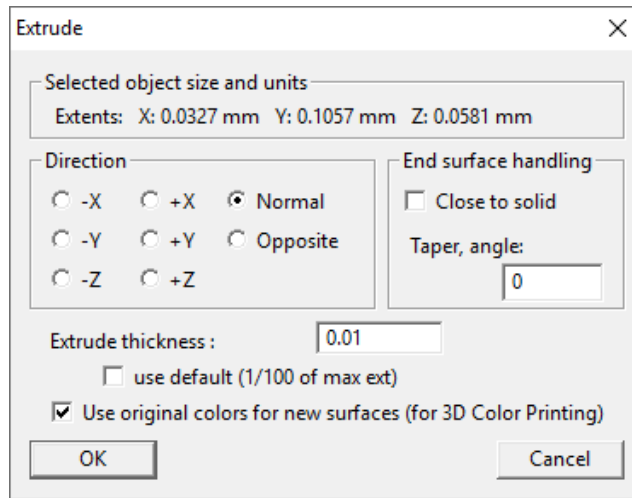


- Then **rotate the eye point** to see the surface facing the *body* shell
- and **select surface** graphically:



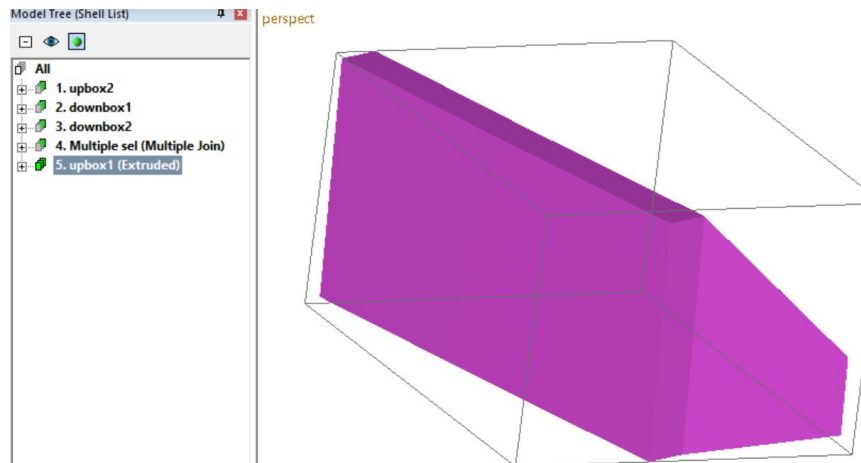
- Then **give command *Create Geometry > Extrude Surface > from Surface***

You will see the following parameter dialog:



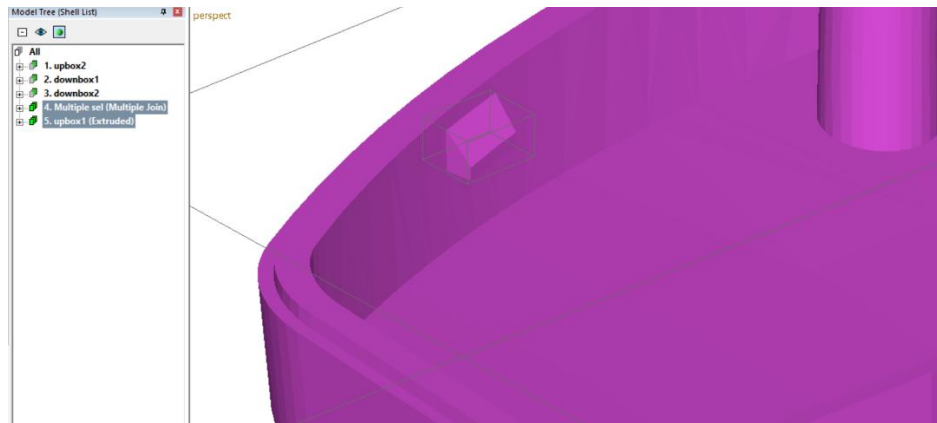
- **fill in the values above** (*thickness 0.01 mm and **untick** the use default*)
- **press OK**

After a while you will see the extrusion result:

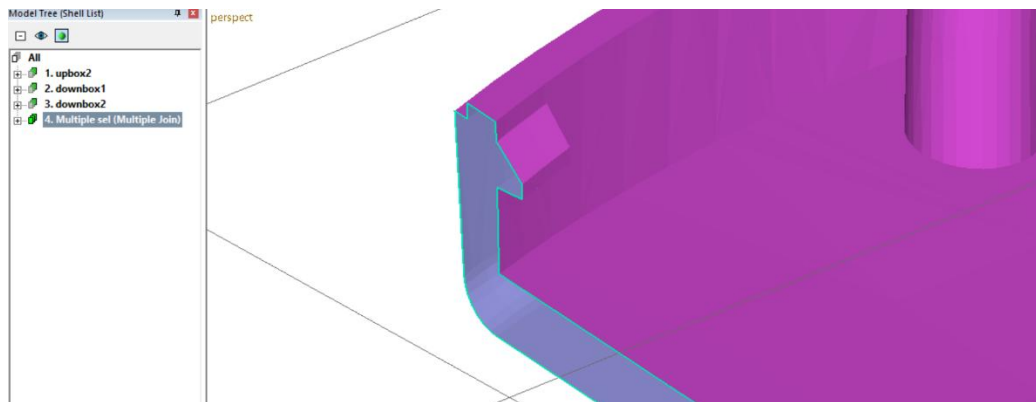


The command moves the selected surface to the (average) normal direction of the selected surface(s) and creates new edge triangles to keep the fixture solid. Now

- **use the multi-selection (*Ctrl + LMB*) to select the *body* and the *upbox1* shell**



- give command **Modify Faceted > Multiple Join** and **press OK** when requested. After the joining we have the two shells properly combined in a single shell, as we can see in this clipped view:

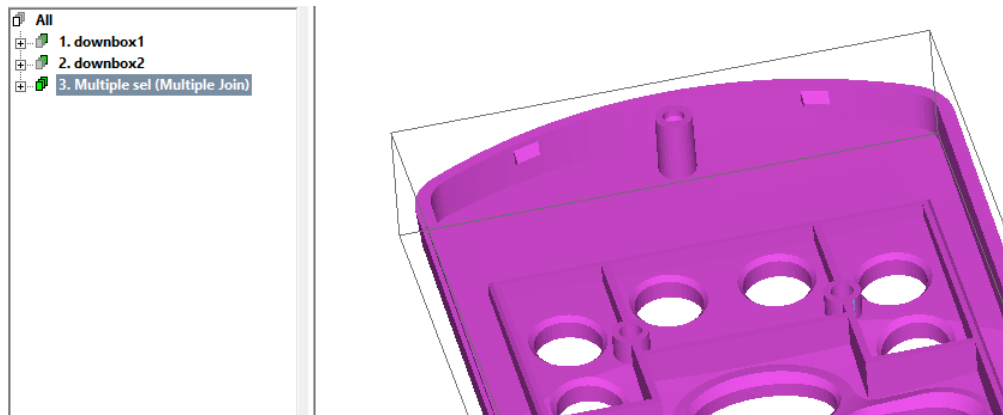


The result now has the two shells connected into one shell 4. Multiple sel (Multiple Join).

Connect the *upbox2* shell to the body in similar fashion,

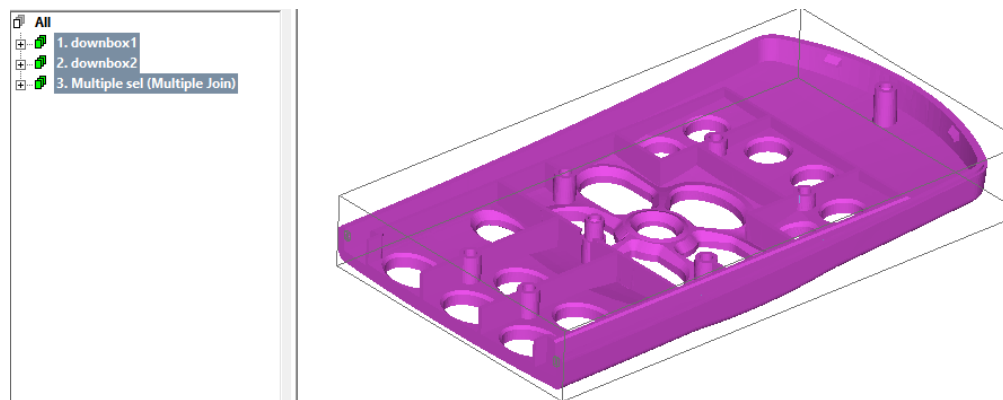
- **select the surface** facing the *body*
- **extrude material with the *Extrude > from Surface*** with the same parameters used in the previous extrude
- **run Multiple Join** to connect the shell to the body

After connecting the *upbox2* shell you should have the following composition in the Model Tree:

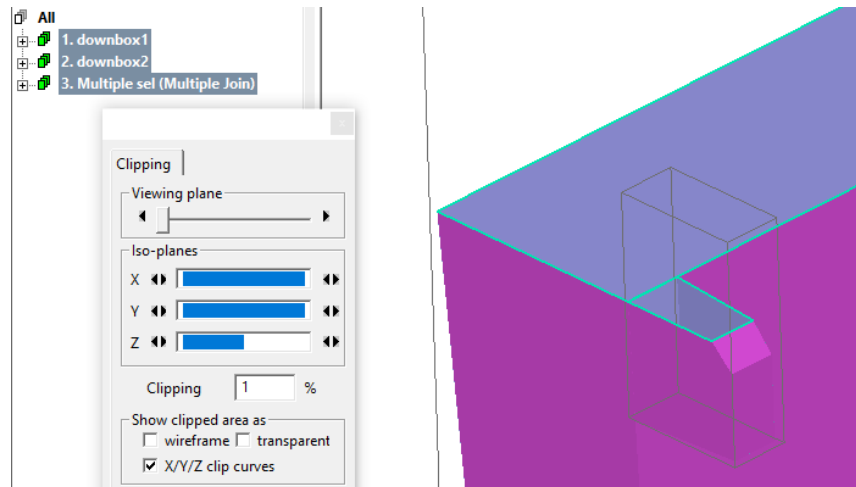


In the last Boolean step, we will connect the *downbox1* and *downbox2* to the *body*.

- Use multi-selection to **select all three shells**



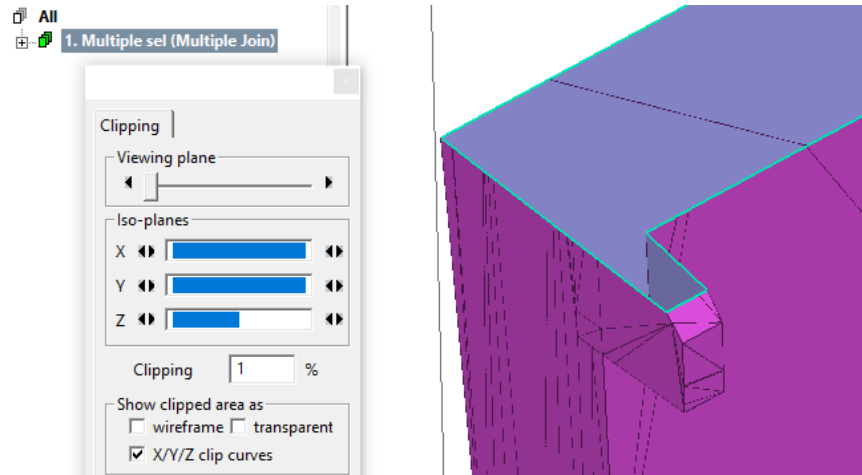
If you do some visual checking with Clipping tool, you will see that the components are tangential:



Most of the time, the Boolean operations with 3Data Expert can handle tangential surfaces, i.e. to connect them correctly. Just proceed with

- **command Modify Faceted > Multiple Join** for the three shells

After a while you will see the three shells connected into one *body* shell:



If the result of the Multiple Join command is not correct, you can use the same extrude method as with *upbox1* and *upbox2* also for *downbox1* and *downbox2*.

The correct model is stored in the *cellphone-repaired.3de* file in the distribution package.

Conclusions with the cellphone model

The cellphone model can be repaired using the 3Data Expert software within 5 - 10 minutes by an experienced user. Stitching gaps, adding material and using Boolean allow us to fix the cellphone file in a few minutes. The output result is a fully fixed STL model for 3D Printing or Additive Manufacturing.

Chapter 3 – A human head

The second example will be a VRML model, a human head. The head model can be repaired using the 3Data Expert Base or Lite modules, and it should take less than 5 minutes. The extensive use of Boolean operations makes this example unsuitable for the Dimensions module; however, the Dimensions module can be used until paragraph “*Repairing and combining the head and the eyes*”. You may also want to try the self-intersection removal in paragraph “*Repairing and combining the head and the teeth*” on page 44 if licensed to the Dimensions module only.

Start by

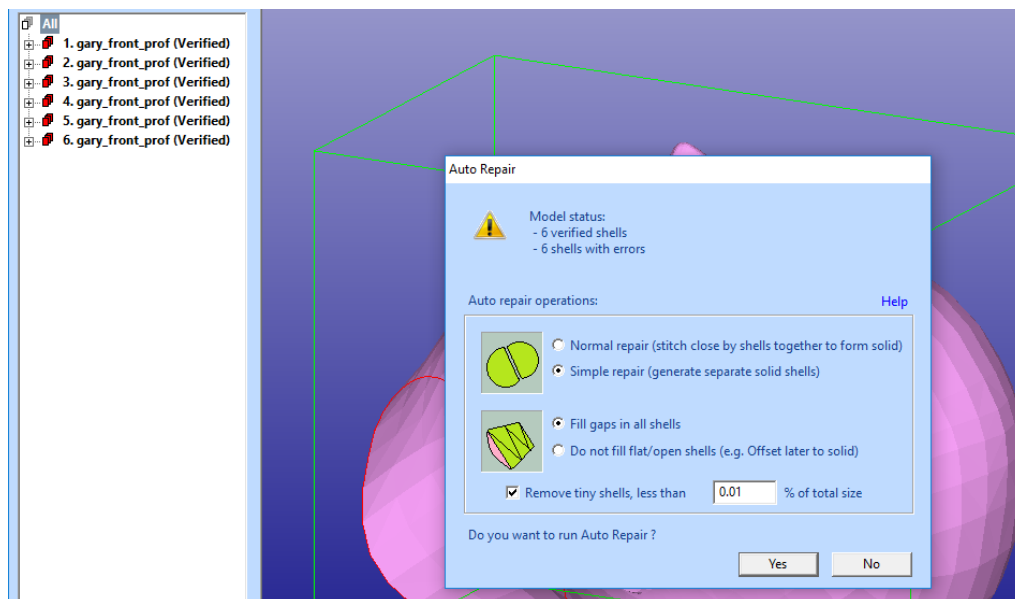
- **inputting the VRML file** *gary_front_profile_bwrl.wrl* with *File > Open* command

you can see the model on the graphics area. For each inputted file the software will ask for the units if not available in the input file. As usually, accept the suggested unit (millimeter) and, from the Operation Mode, proceed to the **Fix mode**.

Analyzing the head model automatically

In the **Fix mode**, the software automatically analyzes the model for errors as well as orients the normals consistently.

After a while the analysis result is shown in the Auto Repair dialog status message:



After the analysis the surface normals are corrected and the outer surface color is changed to pink, the inner surface color remains light blue.

3Data Expert 16.0: STL and VRML repair examples

The model has 6 shells, each with errors. The software asks you if you wish to run Auto Repair immediately.

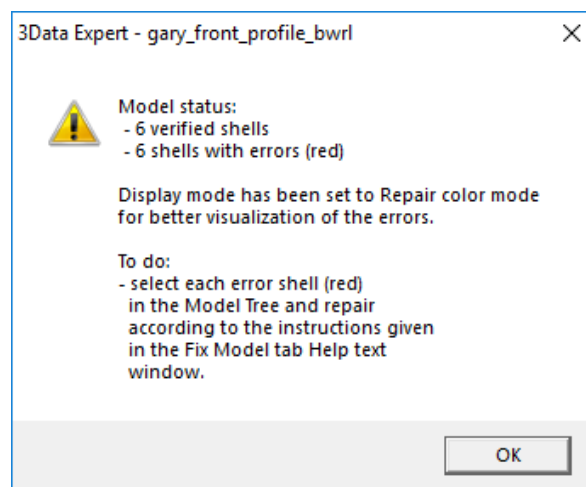
Visual inspection of the errors (gaps) in the model suggests that we should not run the Auto Repair with the *Simple repair* mode, because it would repair each open shell separately into a solid shell. The gaps in this model at the mouth / lip region show that closing them may generate separate shells where shells should be connected to each other at open edges (lips vs. mouth).

If Auto Repair is run with *Normal repair*, the mouth / lip open edges will be connected. You may do a faster repair just by running the Auto Repair with Normal mode and skipping to the chapter *Repairing the teeth*.

However, to learn some important repair techniques, do the following:

- **Press No to Auto Repair** to start a more careful examination of the errors.

You will see the status window appearing:




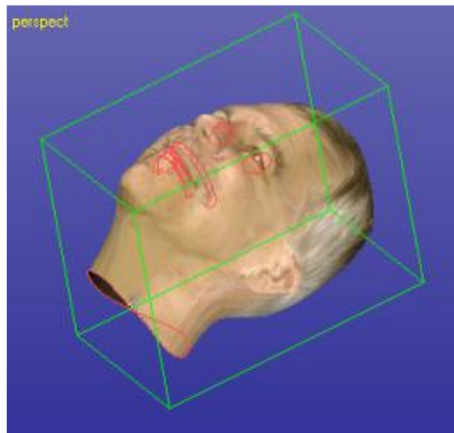
This indicates that each shell has errors, and we should use Model Tree and Help Text to repair the model.


- **Press OK to close the window** and

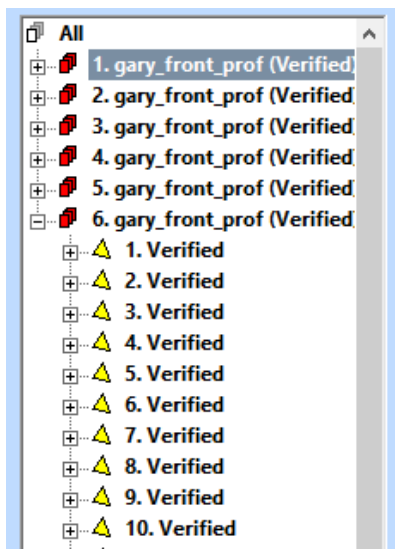
to see the Command Tip window (if not turned off earlier).

- **Press Close** when ready reading the tip, if visible.

Before going to a more controlled use of the repair commands you may want to take a look at the real colors in the VRML file. For that you should turn on the *3D Color Printer* mode for a second. Press the  icon to see the original VRML texture map colors:



3Data Expert can repair and manipulate fully colored and textured models for 3D Color Printing. Now press the  icon again to get back to the *Repair color* mode.

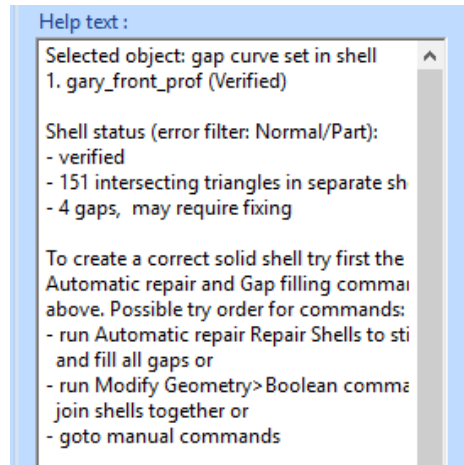


The Model Tree on the left-hand side of the display area contains the directory to the geometrical information for the model. This model contains 6 *shells* (e.g. *1. gary_front_prof (Verified)*, ...). Each shell contains *Verified* triangle surfaces (press + icon to see the *1. Verified*, *2. Verified*. etc. surfaces inside the first shell). The texture information for the VRML data (*.jpg* images) is stored inside each surface.

If you select each shell separately you will see that they represent the eyes, teeth and mouth for the head model. After initial verification the shells are ordered by surface area in descending order.

Now select different shells in the Model Tree and see the Help text window in the bottom of the Fix Help Tab on the right-hand side of the screen. Select the *1. gary_front_prof (Verified)* shell with the left mouse button from the Model Tree:


The message in the Fix Model Tab Help text window tells that there are several *intersecting triangles* (about 151) and *gaps* (4) in the selected shell. Gaps are shown as red curves on the graphics area and stored in the *Gaps* element in the end of each shell in the Model Tree (for example, open the *1. gary_front_prof (Verified)* component and use the vertical scrollbar to scroll to the end of the component to see the *Gap* element). The intersecting triangles are shown with red color in the display area. The intersecting triangles are mostly generated by intersections between the eyes and mouth parts with the 1. shell.

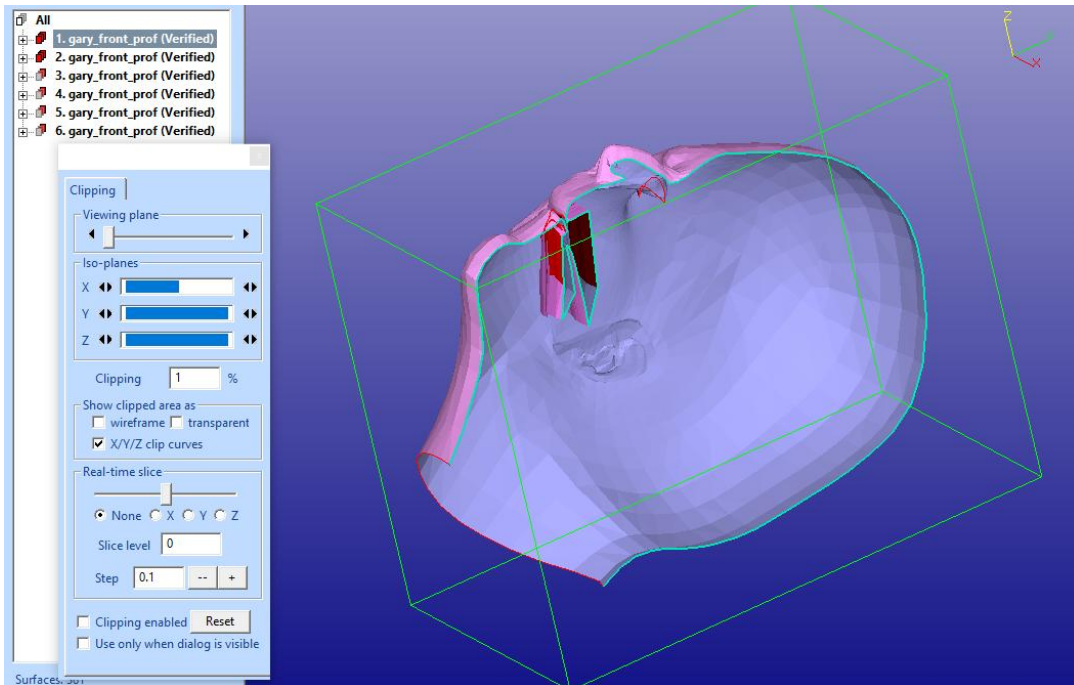


Below the status information the set of possible commands to fix the model are presented. There may be one or more commands and the first is the most likely action to take. Anyhow, you should also use visual inspection to finally decide the command to run.

The input file is divided into 6 different shells in the Model Tree; the original head consist of these disconnected components (eyes, teeth, mouth ...). In the sequel, all gaps will be closed and the components will be connected into one correctly oriented part.

Analyzing the head model visually

Some visual inspection very quickly shows us that the 1. shell (head) should be connected with the inner mouth shell (2. shell). In the image below the two shells are displayed (non-displayed shells are grayed out in the Model Tree) and clipped to display the inner structure of the model (the Clipping Window can be displayed by pressing the  icon):



We can use different visual aids to define the order how to fix and combine the different components together (see the image above). Several viewing commands are available in the *View* menu as well as the Viewing Toolbar and Clipping Window functions do determine the best way to go forward. For example, we can have a look at the model using clip form +X direction and a thick light blue clip curve, as seen above.

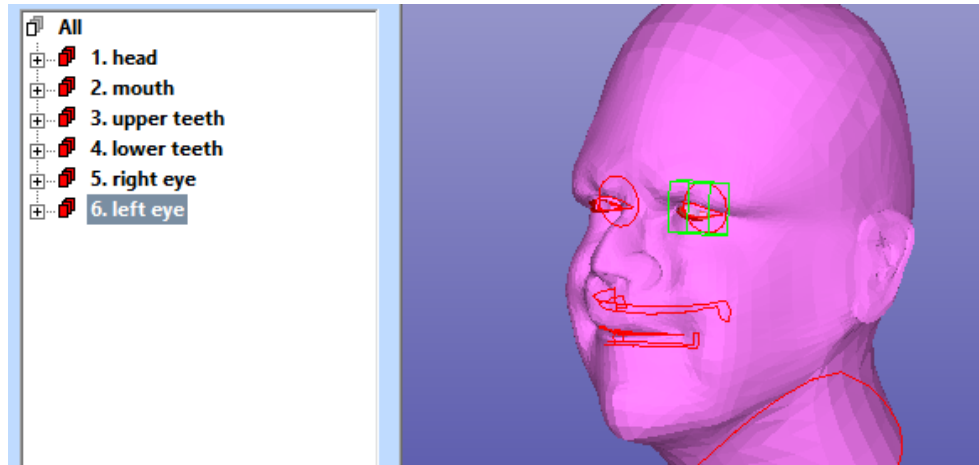
Investigating the verified model visually will show us that one possible way to go is to repair and combine the parts in the following order:

- stitch head and mouth into one correct shell
- repair eye shells
- repair teeth shells
- join all shells with Multiple Join command into one shell

Before starting the repair operations, lets

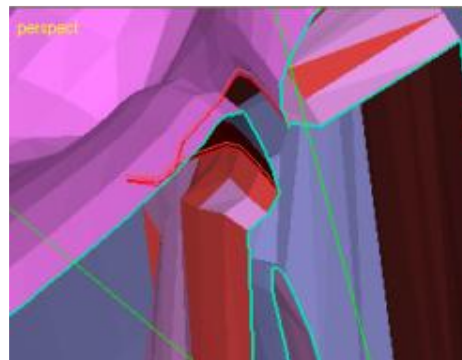
- **rename the different shells** with more descriptive names


with right mouse popup menu on the Model Tree item + *Rename* command. This will help us to keep better track on different parts during the repair process. Below we can see the renamed components.



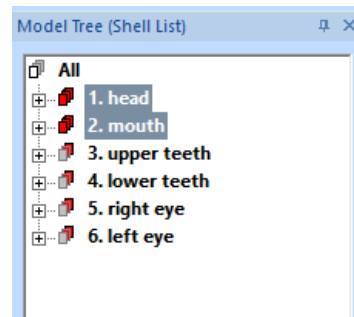
Repairing and combining the head and the mouth

With the head and the mouth we will use the automatic *Fix Model > Repair Shells* command to combine the mouth to the head at the lip area. Stitching the mouth edges into the lips (see below) will produce a desirable result.



We can see that both the disjoint shells are more or less at the same distance from each other along the open edge. The approximate distance can be measured using the *Dimensions > Distance* command and it will give approximately 0.05 units (you can also use the  icon to start the *Distance* command).

Before running the *Fix Model > Repair Shells* command we will use the multi selection (*Ctrl + left mouse button (LMB)*) to select both *head* and *mouth* components in the Model Tree.

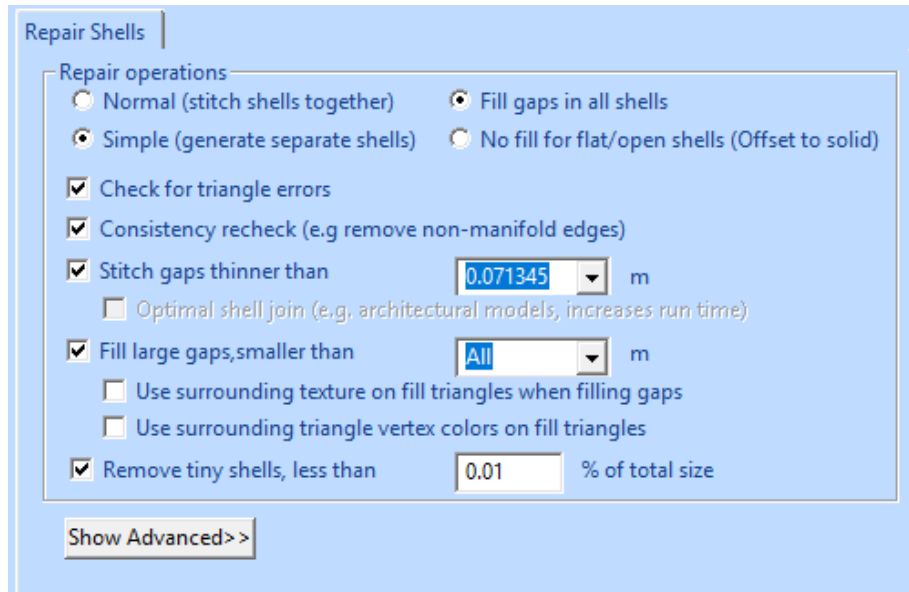


Now

- **select the two shells** with multi-selection, first the *mouth*, then the *head* (the last selected shell will give the name to the result)

- run the **Fix Model > Repair Shells** command from the menu or use the command Fix Model Tab shortcut  button.

You will see the following parameter window:



To get good results, we must give correct parameter values for the repair process. As seen above, normally we want *Check for triangle errors* as we are changing the geometry and we want to know the possible errors after the repair.

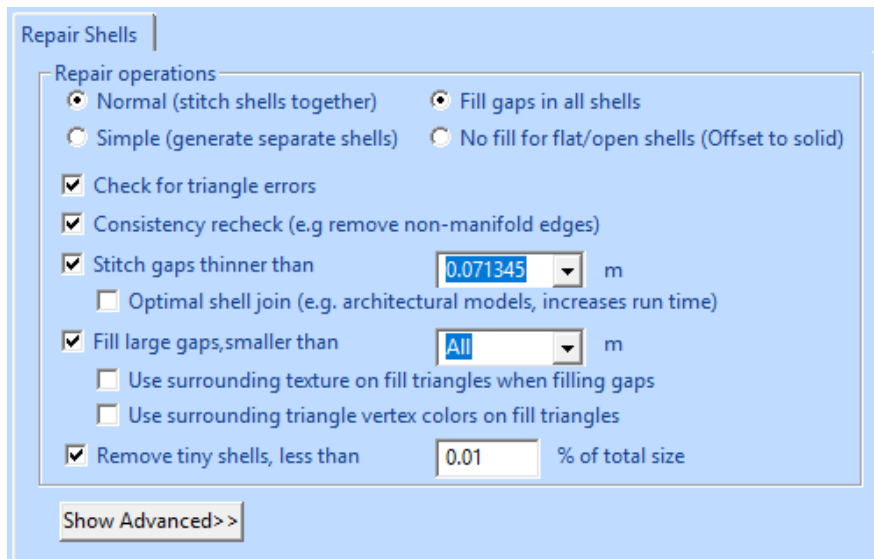
- **Select the *Normal* repair mode.** This will cause the two shells to be connected during the repair at the open edges
- **Fill gaps in all shells** will cause all gap to be filled (there are actually no flat/open shells in the selection)

Stitch gaps smaller than 0.071345 is automatically calculated according to the size of the selected shells. According to our measurements earlier this will connect the shells together by stitching the edges together, i.e. all segments which are closer than *0.071* units from each other will be combined. *Fill large gaps, smaller than* and value *All* will fill the remaining large gaps (neck and eye slots) to form a solid model.

Note: you must be careful when filling the *Stitch gaps smaller than* value. If a too large value is given some edges may be connected to edges too far away, causing new errors.

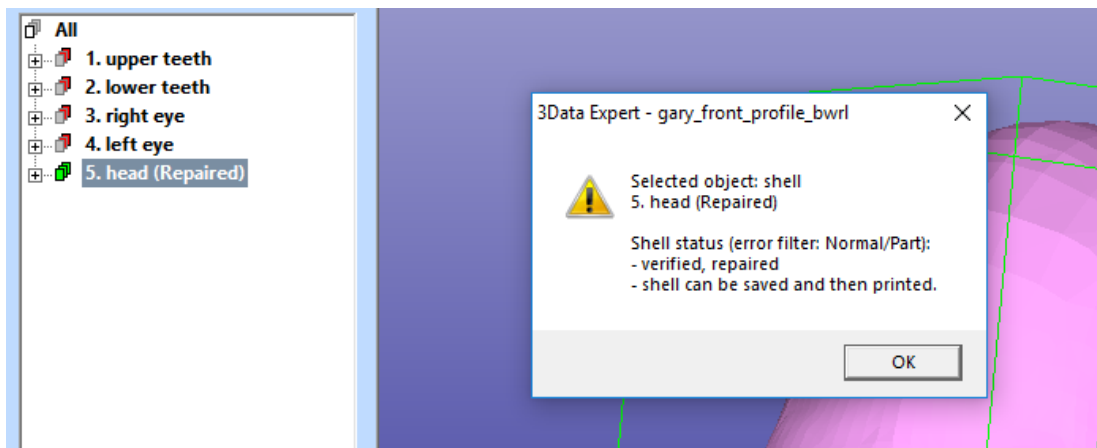
The *Advanced* parameters are not needed with this example.

With the head model we will accept the other parameters seen in the image below.



- **press OK** to start the **Repair Shells** command

After a while we will see the correct result and the message



The original parts have been deleted from the Model Tree and the result will be stored in the end of the Model Tree, *5. head (Repaired)*.

(If the name of your result shell is *5. mouth (Repaired)*, you selected the two shells in opposite order. In that case you should rename it to *head*).

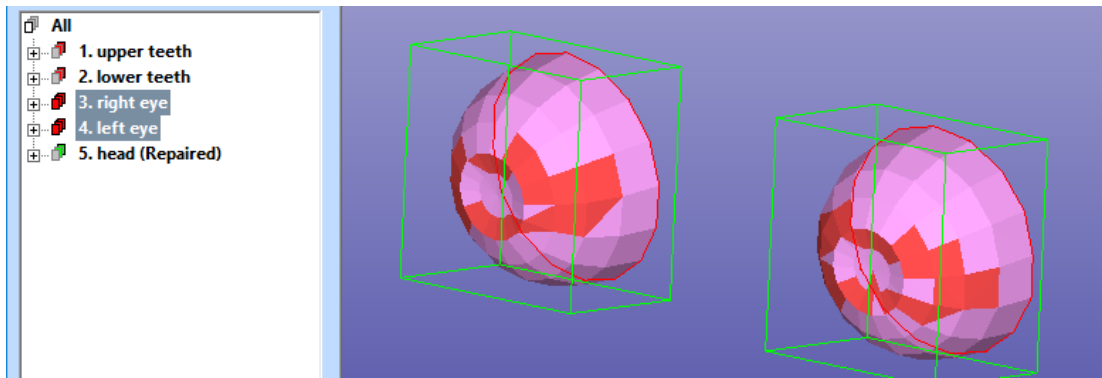
- **Press OK** to close the message dialog

Repairing the eyes

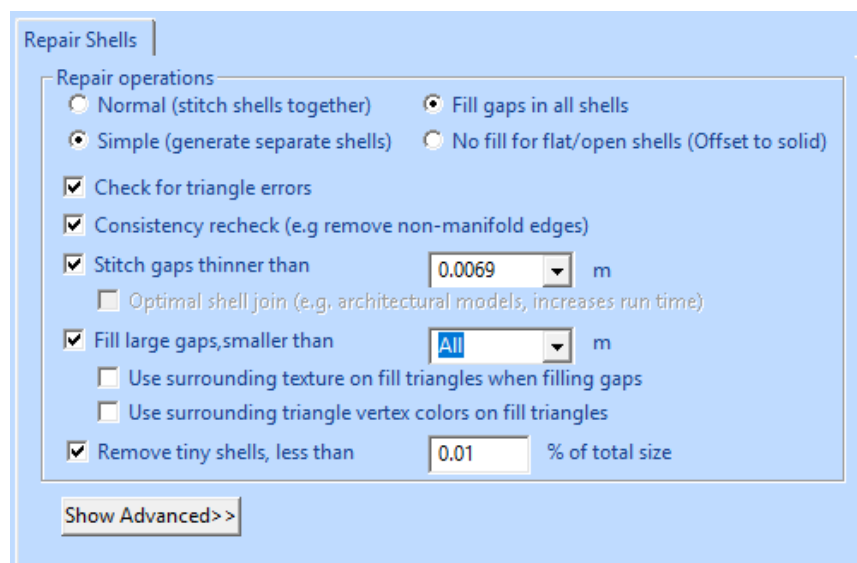
In the next step we will repair the *eye ball* shells to prepare for combining them with the head shell later in the process.

First, we will

- **select both eye shells, *left eye* and *right eye*,**
for the second *Fix Model > Repair Shells* command. The selected shells are fitted on the graphics area in the image below:

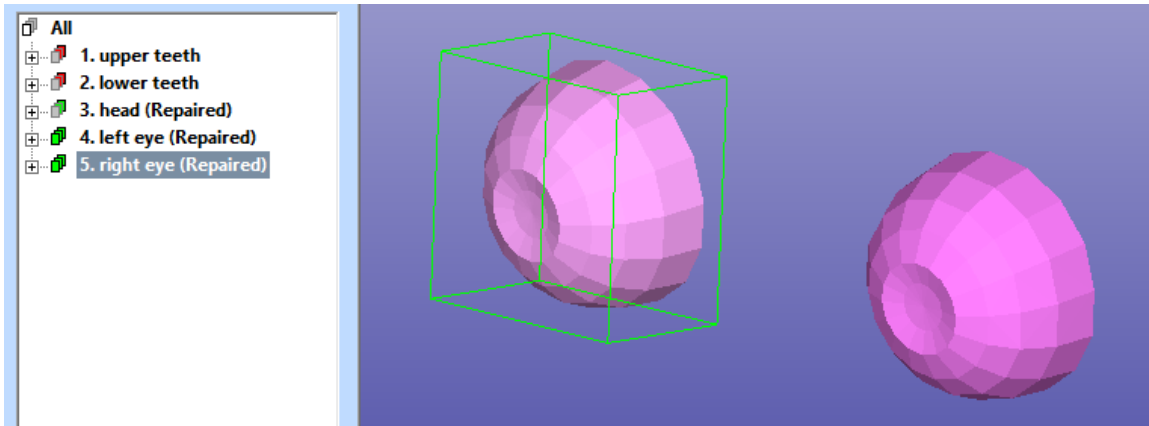


- **Give command *Fix Model > Repair Shells***
The parameter dialog is displayed.
We will use the default parameters:



- **Press OK** to run Repair Shells command
- **Press OK to close the following status** dialog

And you will see two correct eyeballs in the end of the Model Tree:



Repairing the teeth

Next, we repair the teeth shells to be connected to the head shell later. First we will run *Repair Shells* command individually on both teeth set, *upper teeth* and *lower teeth*, to get a solid STL data for the following Boolean operations.

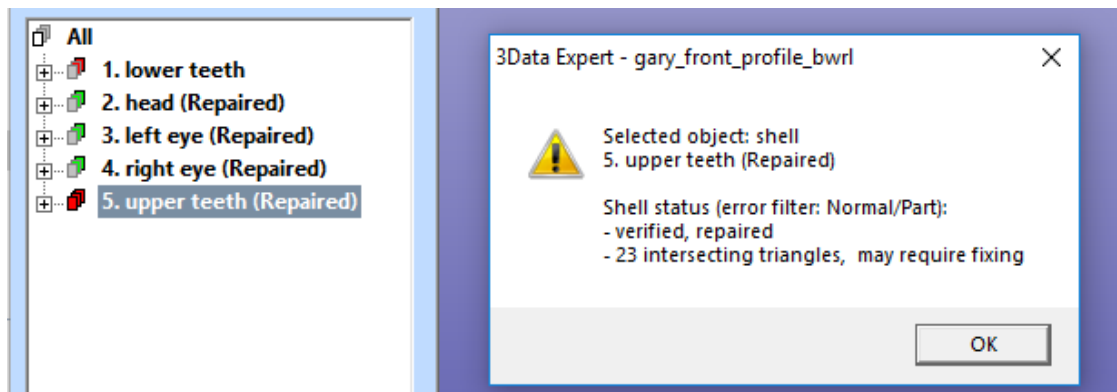
- **Select the *upper teeth* shell** and
- **run the *Fix Model > Repair Shells*** on the selection.

Use the automatic parameters.

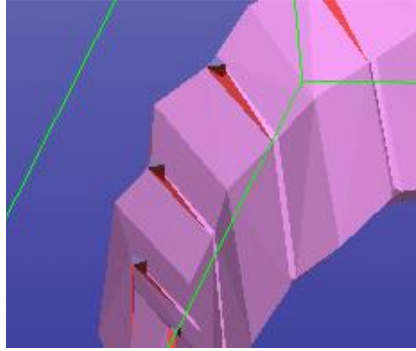
Note: *Repair Shells* is the second preferred command in the Help Text window in the Fix Models tab (first proposal *Join Gaps* cannot be used as there are no similar gaps close by).

- **Press OK** to start the Repair Shells command

After a while you will see the result



The software reports *23 Intersecting triangles* error. A closer investigation (red triangles in the image below) shows that the intersecting triangles are piercing through the outer surface.



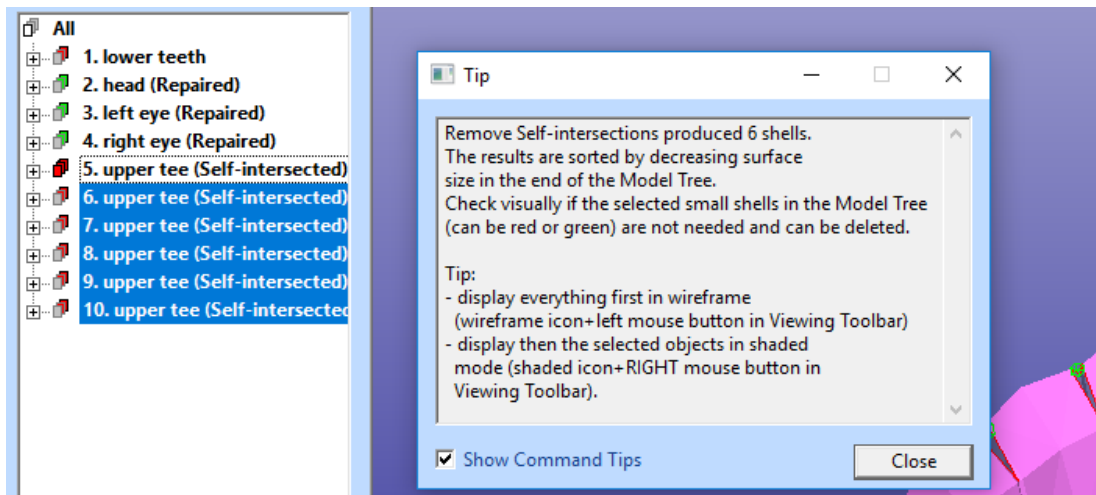
In the Fix Model Tab Help text window the most recommended repair action is to run *Remove Self-intersections* command.

- Run the **Fix Model > Remove Self Intersections** command on the *upper teeth* shell now.

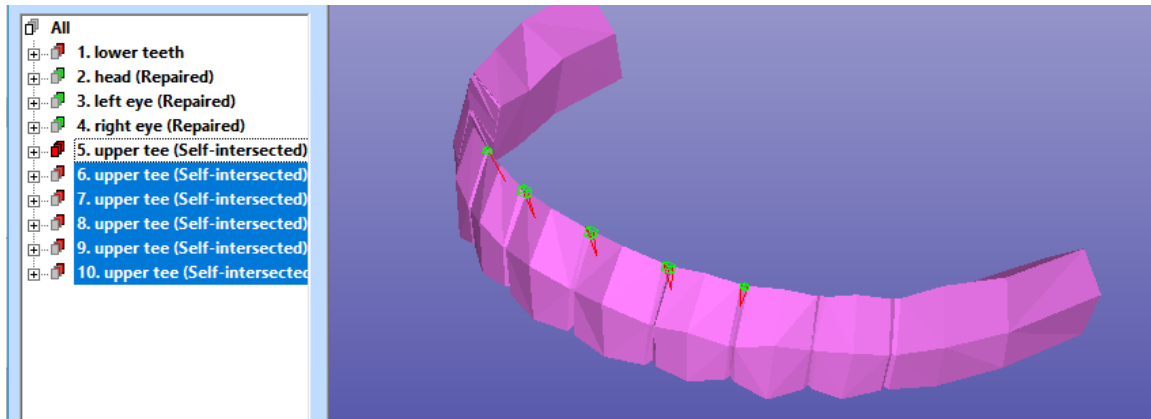
The command can also be started from Fix Model Tab shortcut button.



After a while the self-intersection result is displayed with Tip window (unless turned off earlier):



The Tip window (if visible) indicates that the shells preselected after the command is run can be deleted. These are the small pieces generated by the self-intersection removal and can normally be deleted from the result; the largest shell is the one before the preselected shells and is normally the correct result. Anyhow, you should always visually check that the correct extra shells are removed. With this example the visual check also supports the proposed removal of the shells 6 to 10, as seen on the next image:



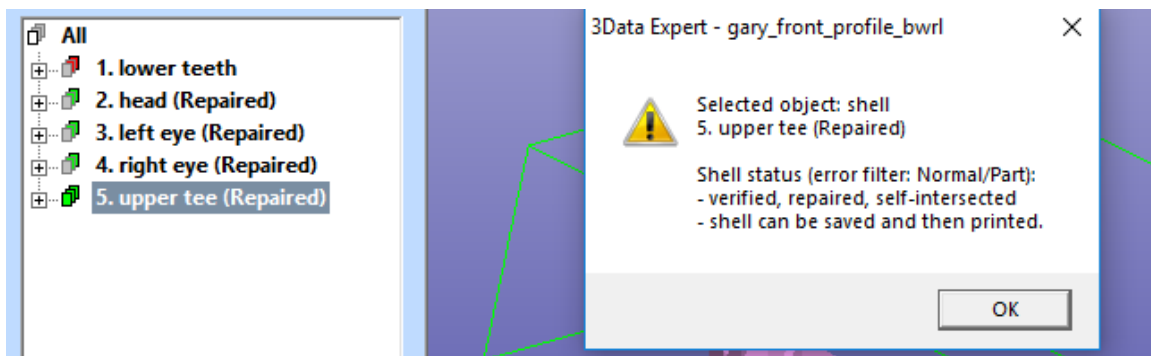
- **Delete** the extra shells with **Edit > Delete** command

or by pressing the Fix Model Tab delete shortcut button:



The software now recommends that you run the Repair Shells command to fill the gaps generated during the Remove Self-intersections command.

- **Run Fix Model > Repair Shells** command with the automatic parameters now to generate a solid *upper teeth* shell:



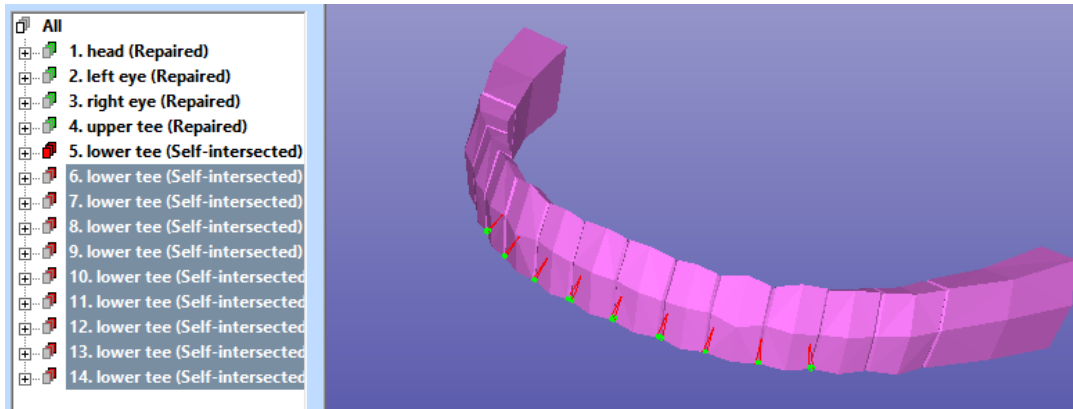
The *lower teeth* are handled in the similar manner. First

- **run the Fix Model > Repair Shells** command to close all gaps

on the *lower teeth* component to make it solid. Once again, there are self-intersecting triangles which are removed by

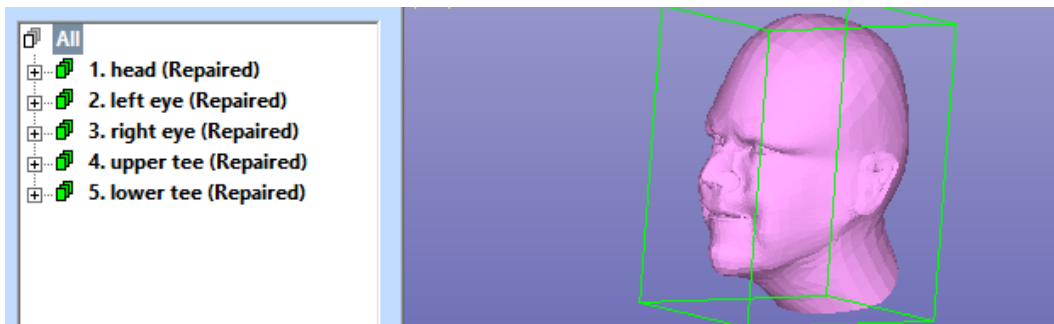
- **running the Fix Model > Remove Self-intersecting** command.

After the self-intersection removal the extra small shells 6 to 14 are again deleted:



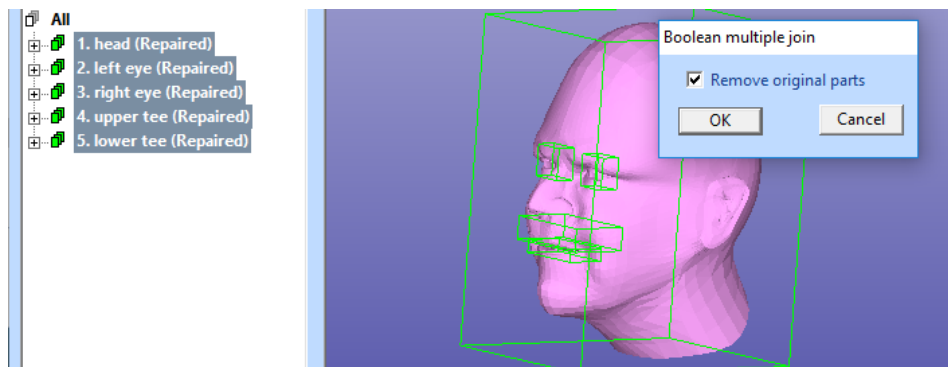
- **Delete the selected small shells now.**
- **Run *Fix Model > Repair Shells*** on the shell 5. To fill the gaps and create a solid shell.
- **Press OK** to close the status window
- **give View > Fit for the root node All**

Now we will have a model with 5 correct shells to be connected into one final shell.



We will use multiple selection to select all parts and then run the *Modify Faceted > Multiple Join* command on them.

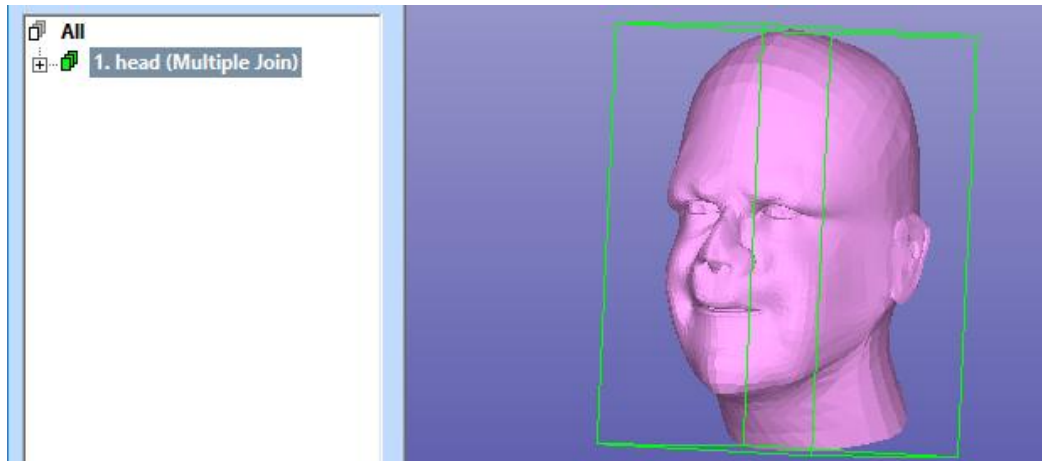
- **Multi-select all shells** in the Model Tree and
- **Start *Modify Faceted > Multiple Join*** on the selected shells:



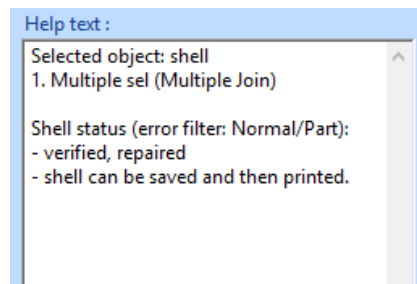
- **Press OK** to run Multiple Join with *Remove original parts*

3Data Expert 16.0: STL and VRML repair examples

A progress bar is shown for each shell to connect (1/5, 2/5, ... 5/5) and soon you will see the correct head (if necessary, rename the result shell to head shell):



The Fix Model Tab Help texts shows that the model is correct too:



Outputting head STL and VRML files

The STL output of the file is straightforward, just select the model and **give File > Save As** command with the STL option. Also, outputting to 3D Color Printing can be done easily by selecting either VRML or ZPR file formats.

The correct file *tutorials / GeomFiles / head-repaired.3de* can be found in the installation package.

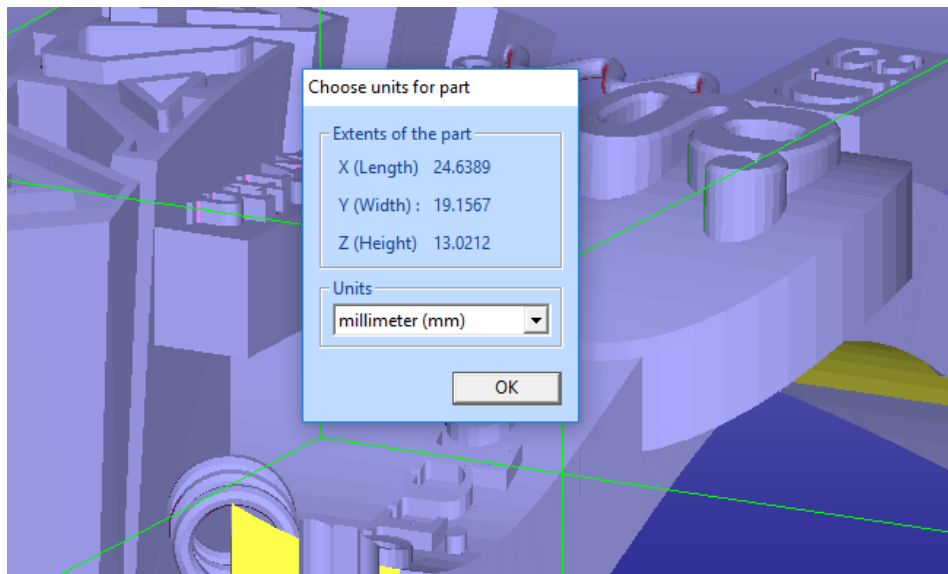
Chapter 4 – The Maya model

The third model to fix will be a test part generated with Maya software (*maya_three_d.wrl* in the example package). The maya model fixing should not take more than 10 minutes with 3Data Expert.

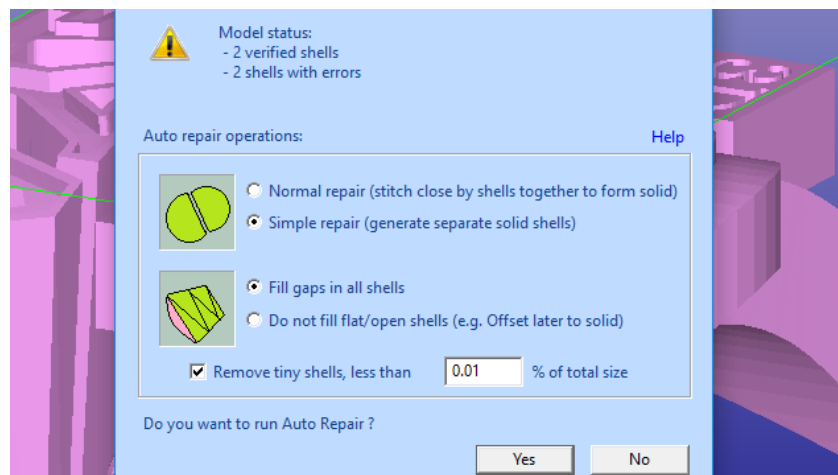
Start and

- **Open the file *maya_three_d.wrl*** with File Open dialog.

After the input we will immediately see that the model is not oriented correctly, there is a lot of blue color inside (inverted normal) visible amongst the material colors (normal side) inputted from the VRML file.



- As usual, accept the units and proceed to the **Fix** mode **to start the analysis**; after a while you will see the Auto Repair dialog with Model status message:

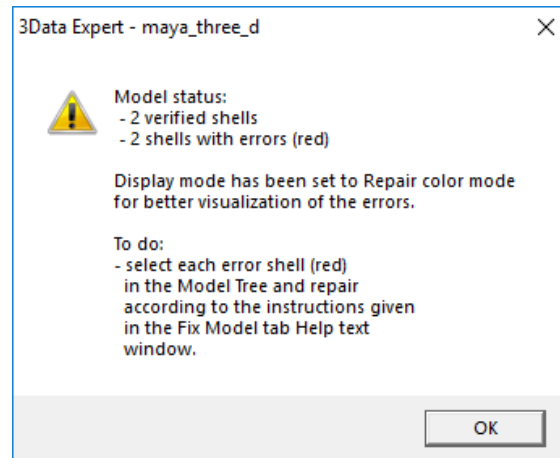


3Data Expert 16.0: STL and VRML repair examples

The normals are now consistently oriented and the repair color is set to the normal sides of the triangles (the original material colors are stored for the 3D Color Printer mode). There are also a few gaps visible on the screen. We can see that there are errors close to the “created with” text. Running Auto Repair may join the small details in the letters in a way which may cause difficulties later with the Boolean operations, so we will

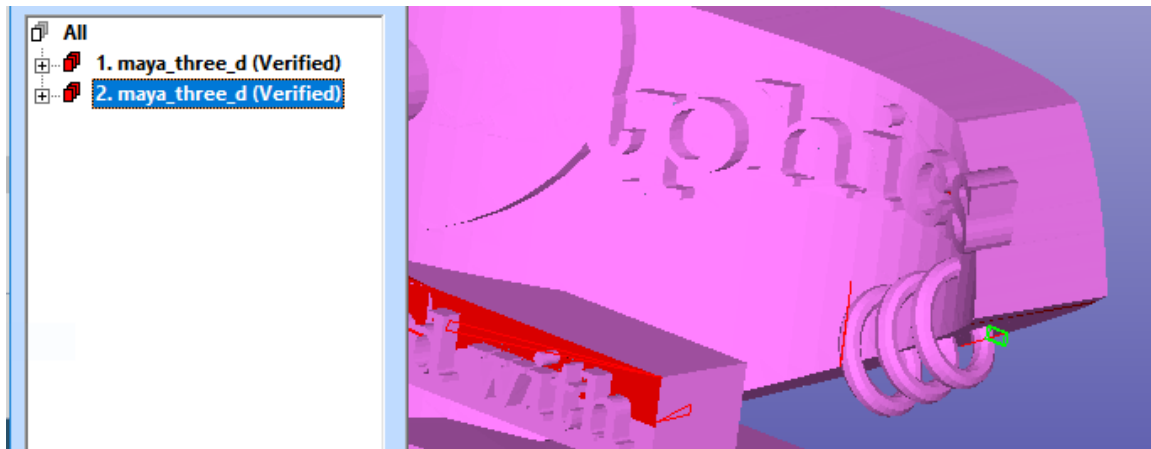
- **press No** to the Auto Repair question

The familiar status message appears:



- **Press OK** to close the window, also **Close** the Tip window appearing if set On through the Help menu.

We are left with two shells, as seen here:



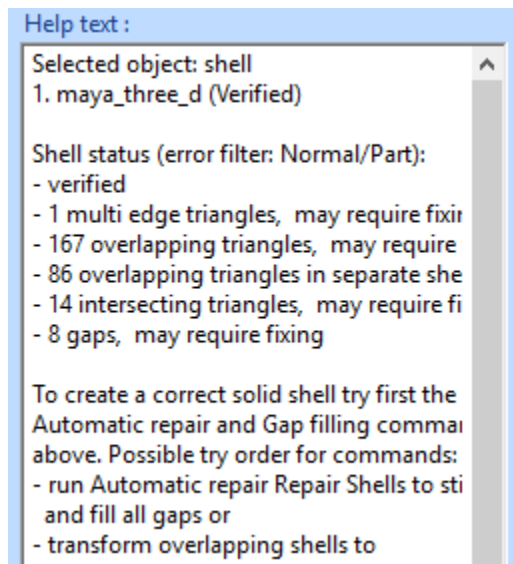
We can immediately remove the second shell:

- **delete 2. maya_three_d shell** from the Model Tree

Now we will select the shell *1. maya_three_d (Verified)* from the Model Tree and have a look at the Help text in the Fix Model Tab.

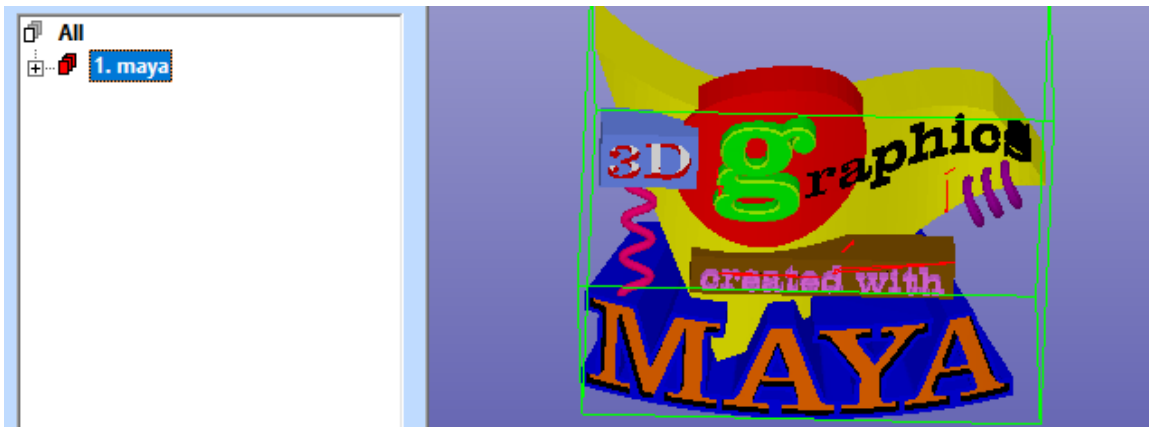
The indicated errors, 167 overlapping triangles are typically the most difficult to fix. This may require removing surfaces manually and then adding some triangles to help correct filling for the gap. Also, re-trimming of some surfaces against each other is sometimes required.

The 14 intersecting triangles are either fixed by Remove Self-intersecting triangles command or Delete triangles / Repair Shells pair. Anyhow, now we must first remove the overlapping triangles to see the real situation concerning the intersecting triangles.



To start, let's rename the shell to shorter name, *maya*. If you now open the Model Tree for the *maya* part, we can see no textures as was the case with the previous head model. Now the model colors are given through the material definitions in the VRML file.

You may now try to press the *3D Color Printer*  icon to see the true colors of the model:



Return to *Repair* color mode by pressing the  icon again before continuing.

Repair steps for the Maya model

The errors in the model are caused by erroneous triangulation of surfaces at the intersections of different model components. First you should investigate visually how serious the errors are.

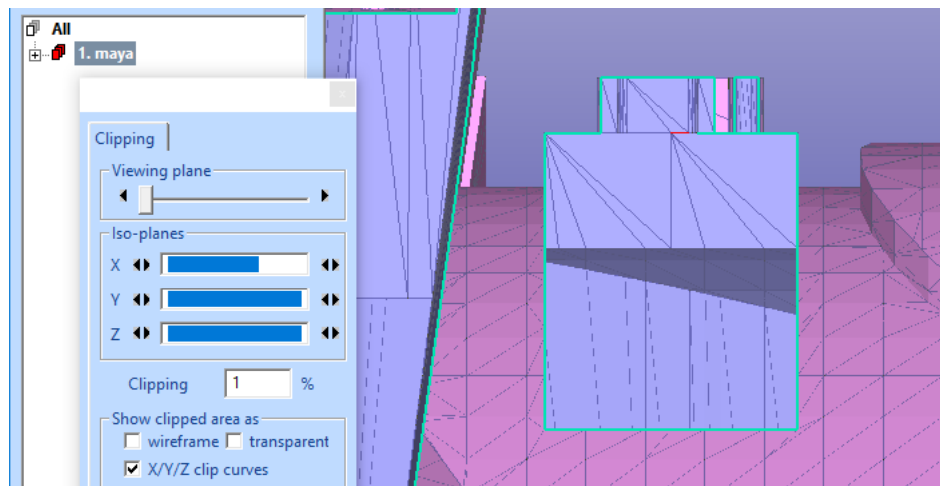
A short investigation reveals that we cannot just delete the erroneous triangles with *Fix Model > Delete Errors > All error triangles* command. Instead, we need to do some

- 1) The “*created with*” text requires to be re-connected to the part for correct STL/VRML file generation.
- 2) The box below the “*created with*” is not correctly trimmed to the curved surface attached to it.
- 3) Manual triangle removal and addition at the string “*graphics*” character borders to help the automatic repair to produce the correct result in the end.
- 4) Gaps should be filled with automatic repair.

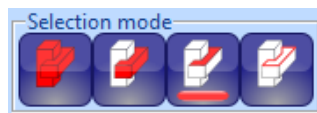
Let's start with the worst problem, re-connecting the “*created with*” string.

Connecting the “*created with*” string

The string “*created with*” needs to be re-connected to the maya shell first. If you take a look from X axis and use clipping, you will see that the text is on a flat surface. In this case we can use the new *flat polygon area fill* functionality available with the Repair Shells command. In the clipped image below you can see that the gaps are on the flat plane:

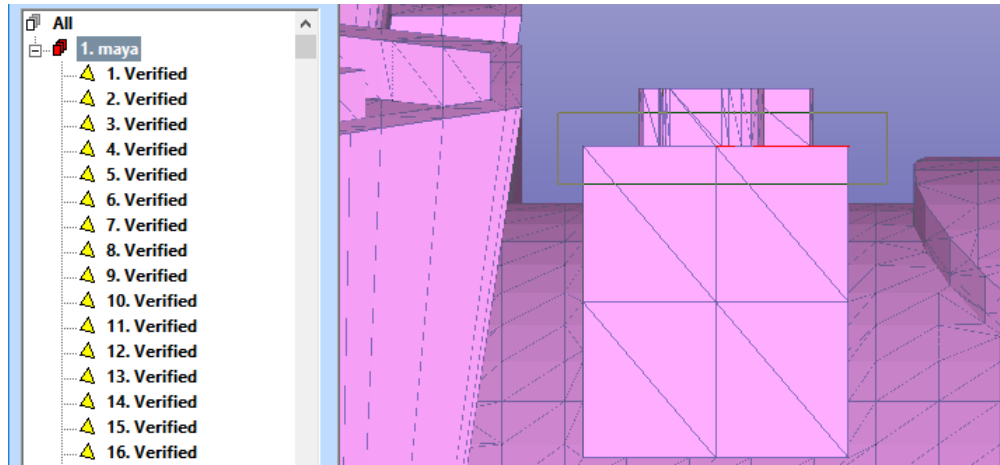


We will first clean up the planar area surfaces the text is attached to. Before selection make sure the *Selection mode* is in the *Surface* selection mode:

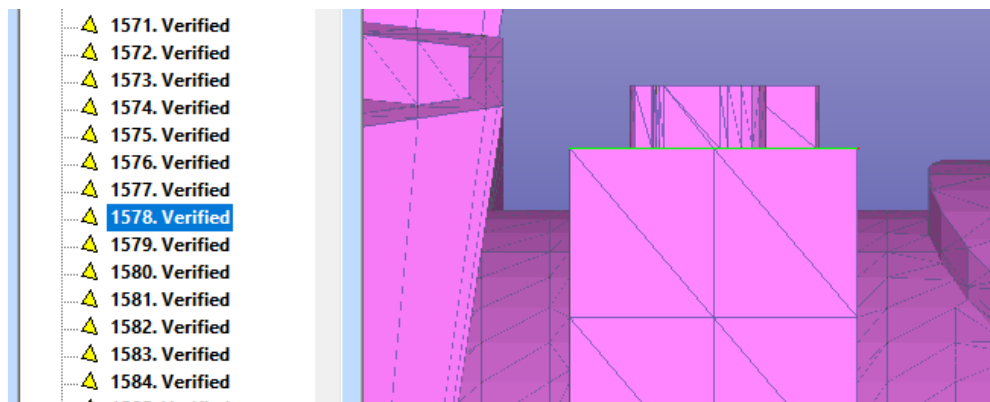


Then

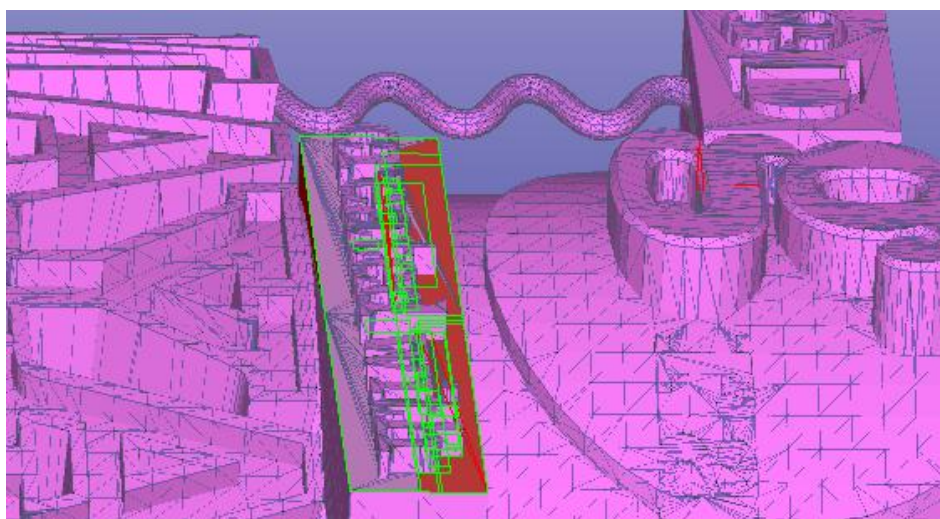
- **take a view from X axis direction**
- **use Alt + LMB rubberband selection** to select the surfaces in the flat plane as seen below



When the mouse is released, the surfaces at the plane are selected:

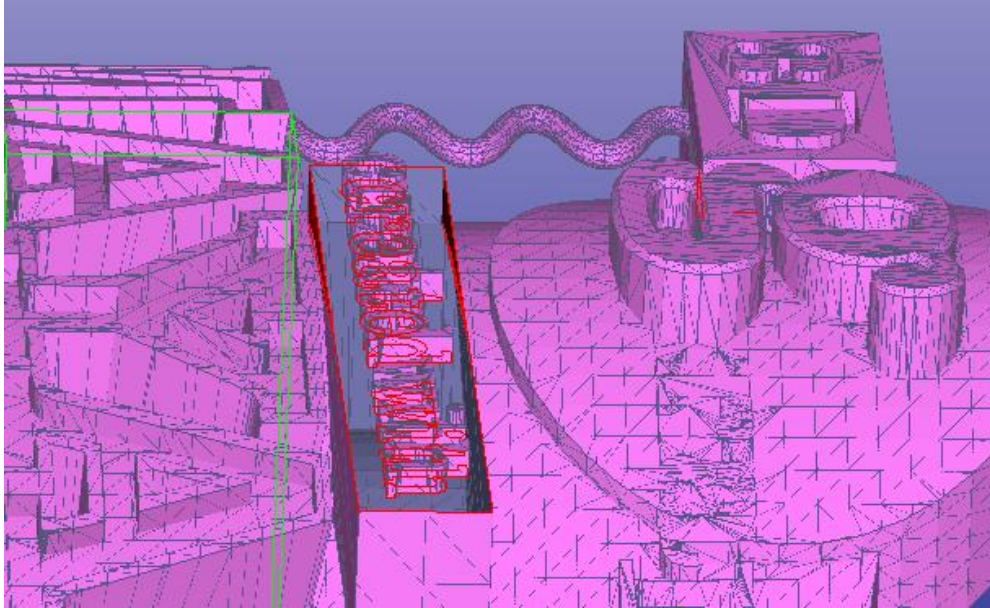


And from another viewpoint:



Then

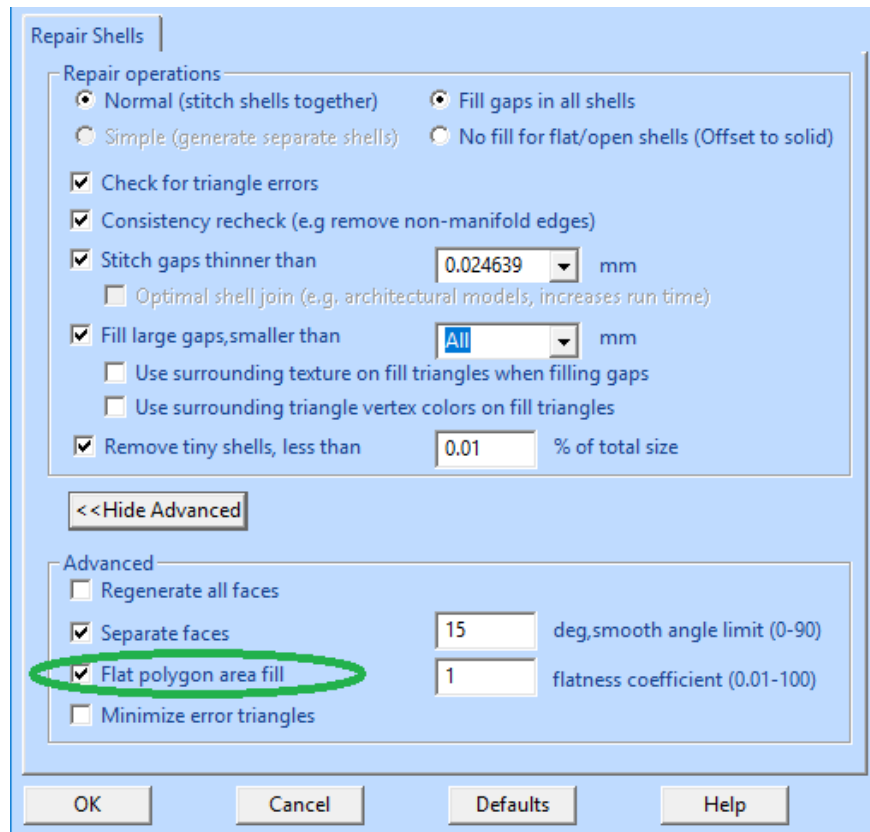
- give **Edit > Delete** command to delete all selected surfaces



Now

- **select the maya shell**
- **give the *Fix Model > Repair Shells* command** to fill the gap between the text and the surrounding area

Soon you will see the parameters dialog:

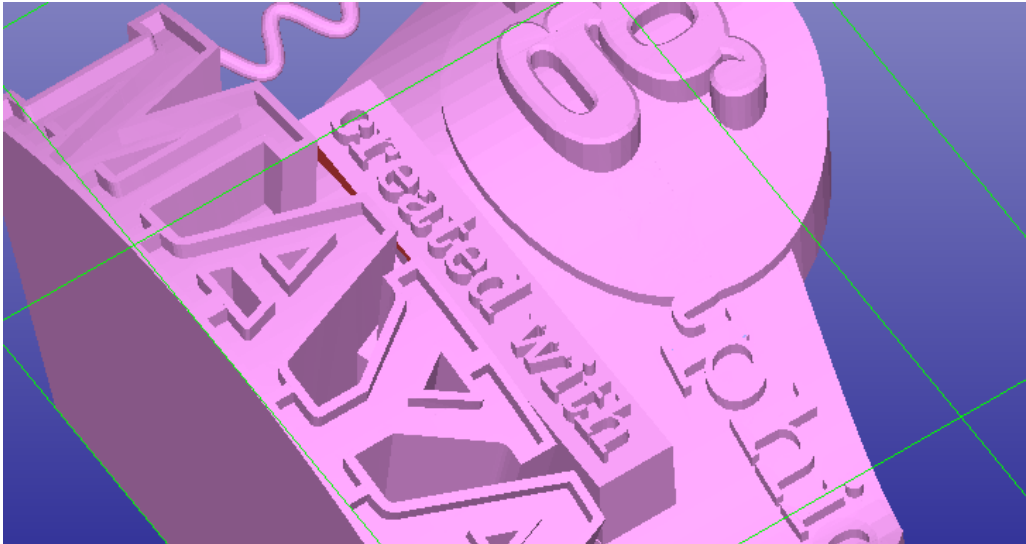


3Data Expert 16.0: STL and VRML repair examples

The *Flat polygon area fill*, set on by default, will connect the flat gap polygons at the letter bottom edges to the surrounding box edges. All polygons lay in the same plane and the software use a special algorithm to fill between the separate polygons automatically.

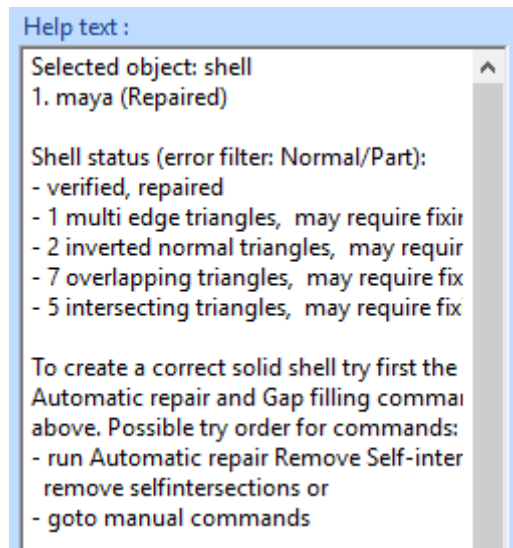
- **press OK to run Repair Shells** on the maya shell.

The result on the text area is a perfect triangulation between the letters and from the letters to the surrounding square gap.




Fast visual inspection shows that the “*created with*” string is now correctly connected to the *maya* component.

The *maya* model would be printable with any 3D Printing system with the current state. Anyhow, there are still a few *overlapping* and *intersecting* triangles and we will fix them for the completeness sake in the sequel. Also, some thin triangles may have caused inverted surface area to appear. This will also be fixed in the sequel.

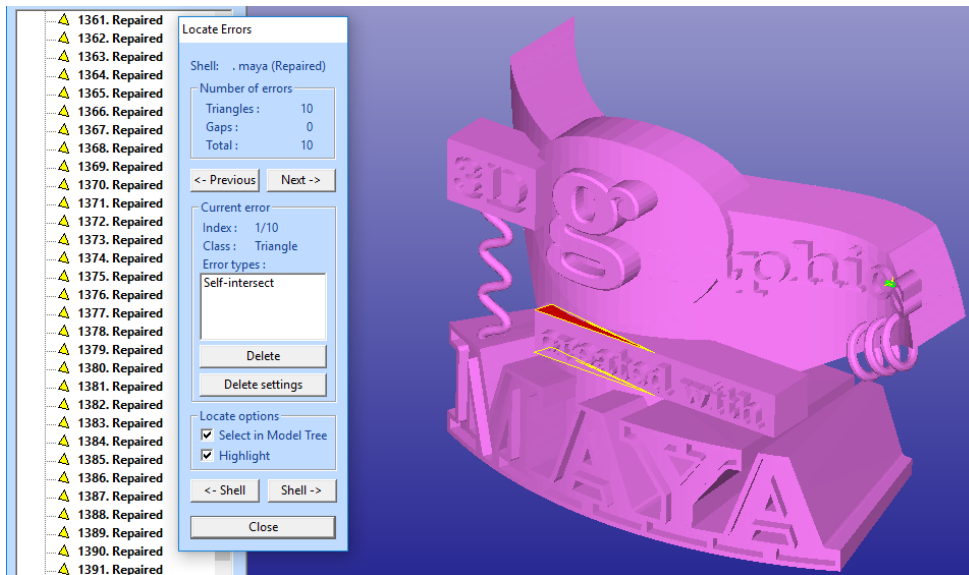


Repairing the text base box

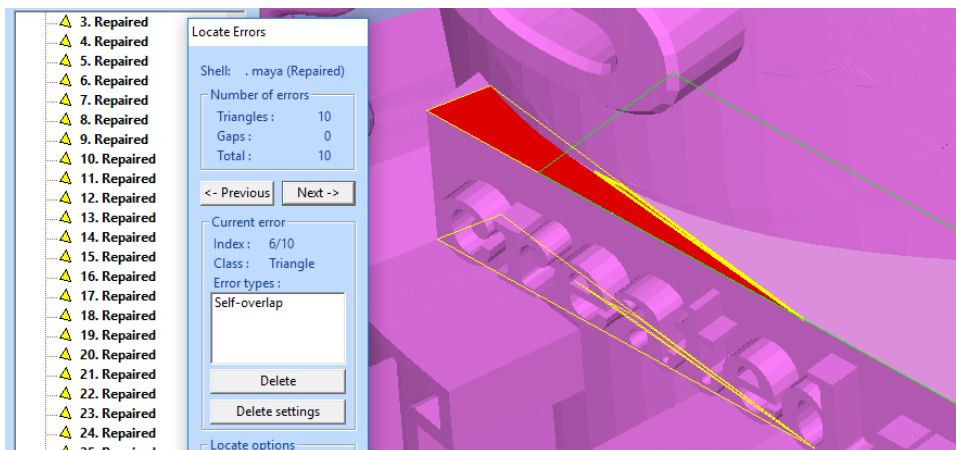
To locate the remaining errors, you can either look for the red triangles on the screen or use the Locate Errors command to highlight the error triangles with yellow edge color and to fit them on the middle of the screen. Locate Errors tool will help you to pinpoint any error triangle or gap in the model.

- Give **Fix Model > Locate Errors** command or press the Locate Errors  button in the Fix Help Tab.

The Locate Errors Window is displayed and error triangles highlighted on the screen. The dialog will give info on the total number of errors in the selected shell, *Previous* and *Next* buttons to select and fit the next error on the display area, error type for the currently selected error triangle as well as buttons to go to the next or previous *Shell* with errors:



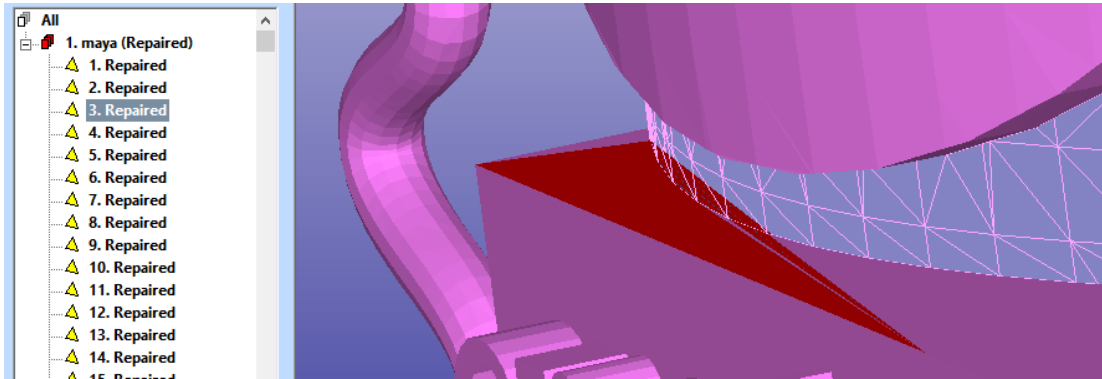
Press the *Next* button on the Locate Errors dialog until the following error triangle is highlighted on the screen:



We will now clean up this overlapping triangle and the area surrounding it. You can

- **close the Locate Errors dialog now by pressing *Close* button.**

The box feature in the model has some overlapping triangles on the upper face, as seen here:



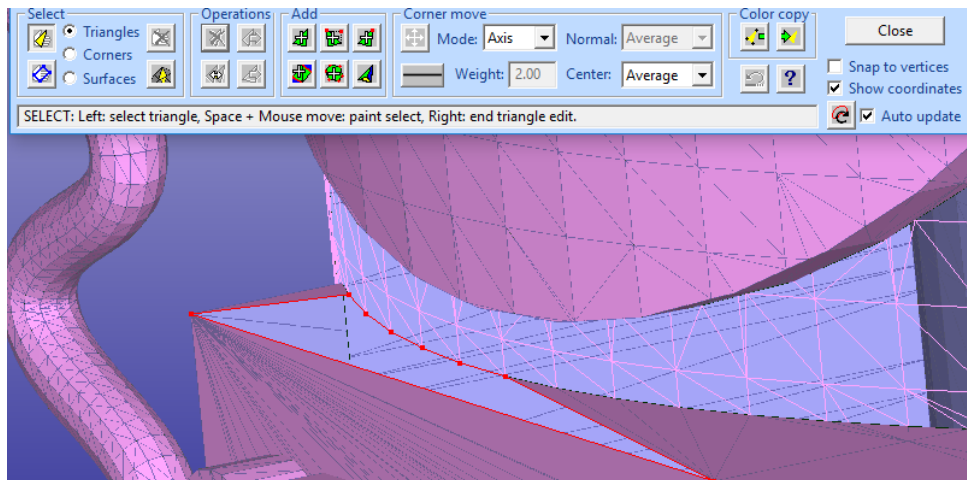
These errors cannot be removed 100% reliably using automatic Remove Self-intersections command due to the tangential intersection conditions. Now we will remove a few triangles manually and then let the *Fix Model > Repair Shell* command to *Fill all* created gaps.

- **Start triangle removal with *Fix Model > Edit Triangles* command** or using the Fix Model Tab shortcut button:



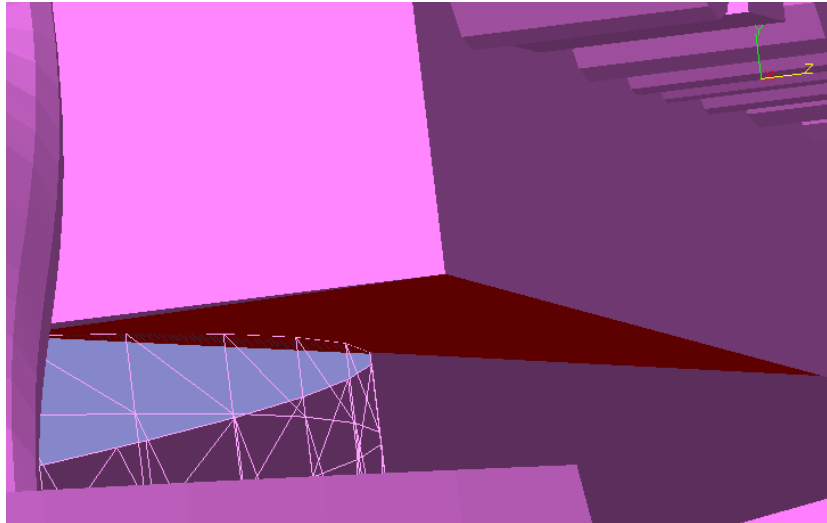
Remove enough overlapping triangles from the error area, as seen in the next image.

You could also use Surface selection mode and LMB selection with Delete to get rid of extra surfaces in the area.

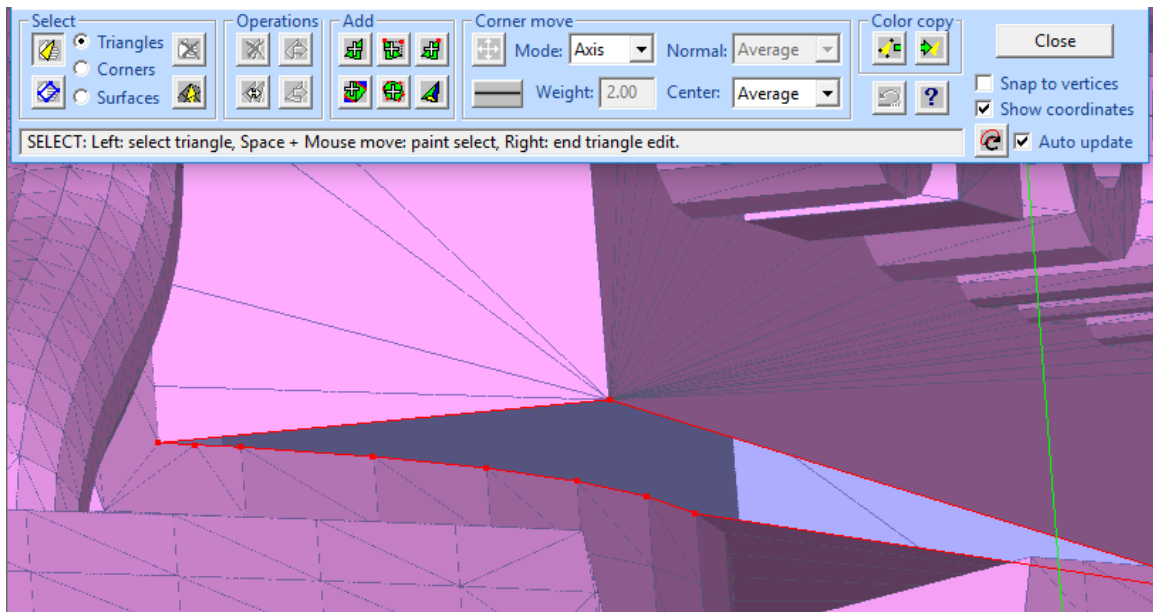


To finish the fixing at the “*created*” string, have a look at the bottom of the base.

- **Select all red triangles and delete** them also on the down surface of the box to allow the automatic repair to fill the gap correctly:



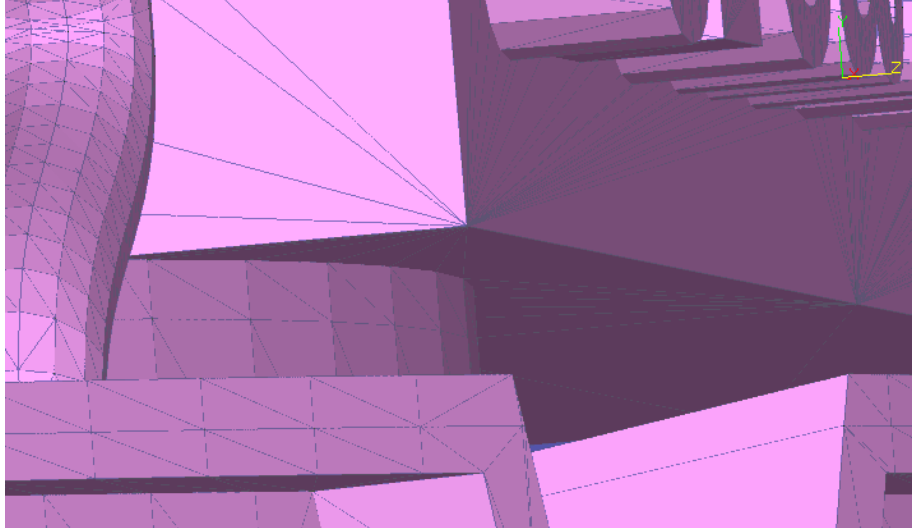
You may use the *mouse wheel zoom* and *middle mouse rotation* during the Edit Triangles command to get a better view to the delete triangles if necessary. After the removal the gap should look as seen here:



After deleting the triangles, you can close the Triangle edit mode.

Then run

- ***Fix Model > Repair Shells*** command and the corrected area is displayed:



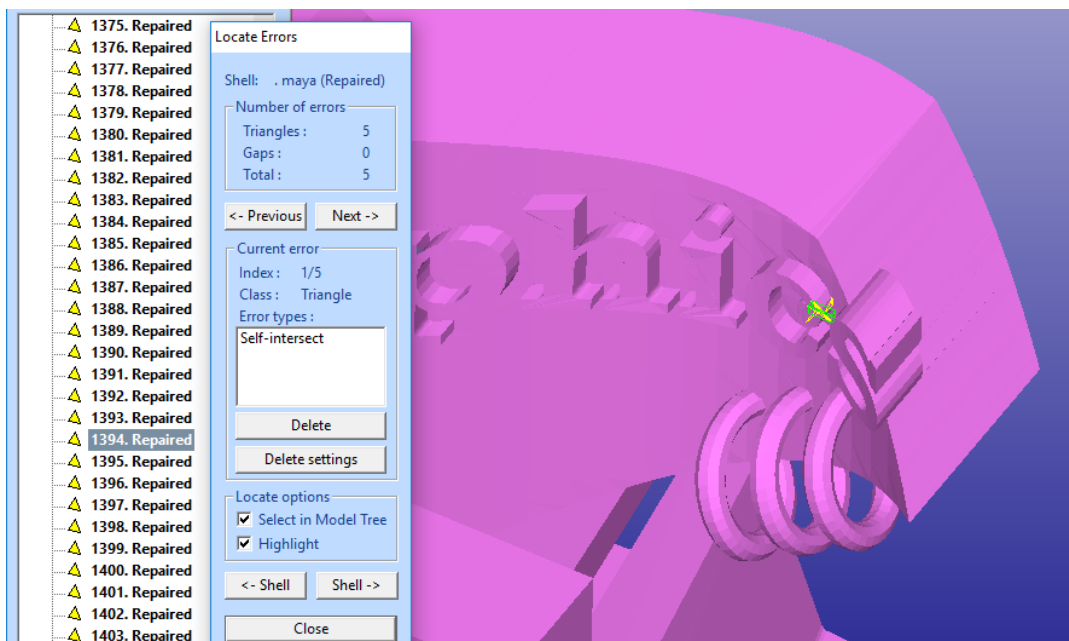
Repairing the “graphics” string

To locate the last remaining errors we should use the *Fix Model > Locate Errors* tool again.

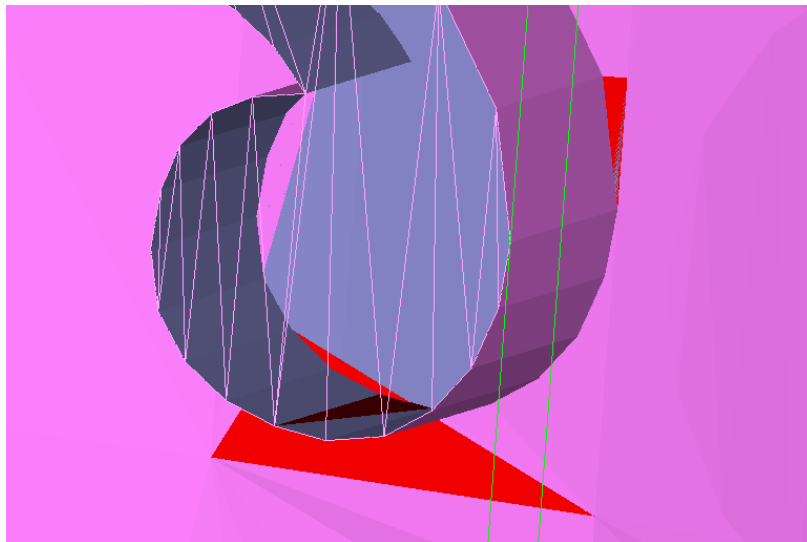
- **Give the command *Fix Model > Locate Errors*** to open the Locate Errors dialog or press the Fix Model Tab shortcut



button. Error triangles in the model will be highlighted with yellow color as seen on the image next page:



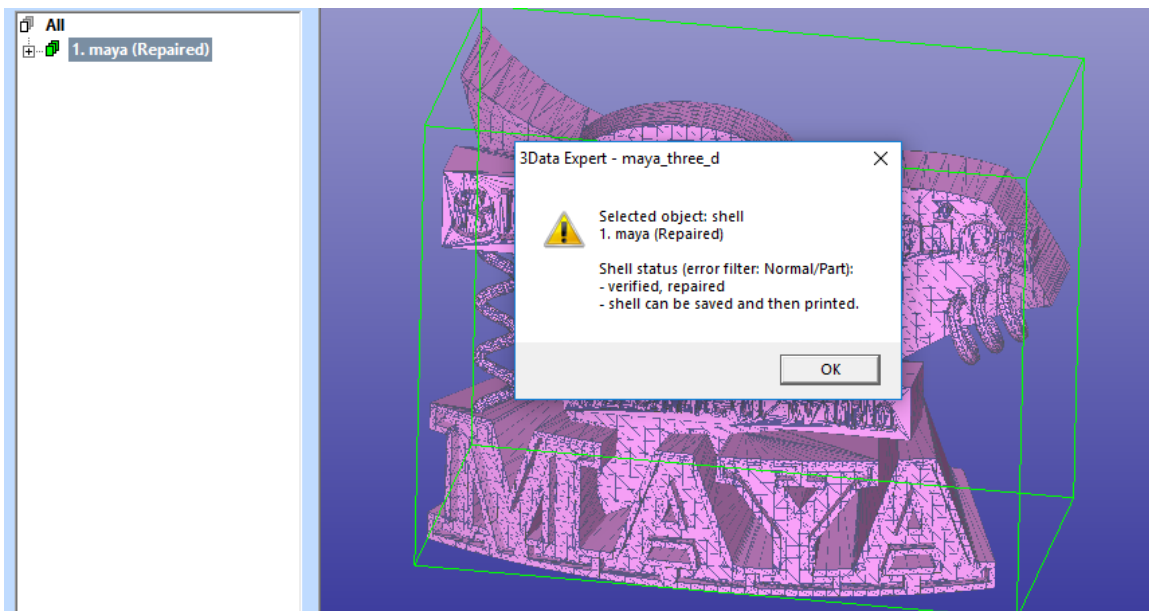
The last errors are at the letter 'c' in the graphics string. **Press Next** or Previous to zoom into the error area and the **close the Locate Errors dialog**. The errors around the letter 'c' are similar to the previous two errors we have fixed:



- **Open *Fix Model > Edit triangles tool*** and
- **remove the overlapping triangles with LMB selection + RMB delete**

Then give

- ***Fix Model > Repair Shells*** command for a gap filling and you will have a correct *maya* model.



Note: You may find a new area or areas at the letter 'p' with similar errors after the last repair, just remove the *overlapping or intersecting* triangles in that case and rerun the Repair Shells once more. Or use *Fix Model > Edit Triangles* to clean up the error triangles, simplify the gaps and rerun the *Fix Model > Repair Shells* until there are no errors.

Outputting the Maya model

Once again, STL, VRML and ZPR output is straightforward *File > Save As* operation.

The correct file *tutorials / GeomFiles / maya_three_d-repaired.3de* is available in the example package.

If your goal is to take the model to 3D Color Printing, you will need to fix some color errors created during the topology fixing. Model coloring is described in detail in the “*Working with Colors*” (through the Help menu).

Chapter 6 – Conclusions

Congratulations for reaching the end of this repair example document! By going through the example models you have learned a lot of the advanced STL and VRML model fixing functions in the DeskArtes 3Data Expert. The handled models are difficult and in the everyday work you should not need all the skills acquired to prepare parts to be build. Anyhow, when a difficult model comes you will now know what do with it!

We have shown that the DeskArtes 3Data Expert can be efficiently used to fix even most difficult geometrical problems. Investment in the 3Data Expert software will pay itself back very fast due to increased throughput of the 3D Printing system or seamless STL model transfer to simulation software.

There are several other commands available in 3Data Expert for generating and handling triangle models. To know more about these commands we recommend you to go through the example documents available through the *Help > Tutorial Documents* command.

Thank you for spending your time with these exercises. We wish you pleasant and productive moments with the software in the future and also ask you not to hesitate to contact us at DeskArtes (support@deskartes.fi) if you have any questions concerning this manual or 3Data Expert in general.