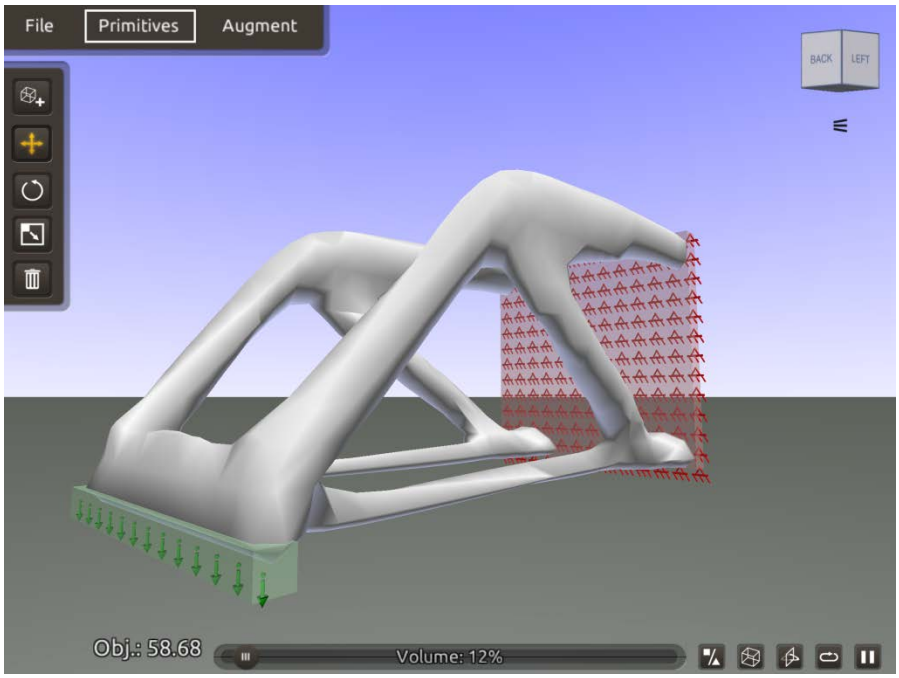
TopOpt 3D UserGuide



by Niels Aage
DTU TopOpt Group
www.topopt.dtu.dk
June 17, 2014

Solid Mechanics, Department of Mechanical Engineering
The Technical University of Denmark, DK-2800 Kgs. Lyngby

Content

1 Getting started

TopOpt3D is an app for iOS, Windows and Mac OSX that allows the user to perform 3D interactive topology optimization in real-time. Information on how to download the app is found at www.topopt.dtu.dk under Applets and Software. This manual explains the menu system and provides turorials to help the user to get started with designing structures in the TopOpt3D app. For a technical explanation of the app the reader is referred to [1,2,3,4].

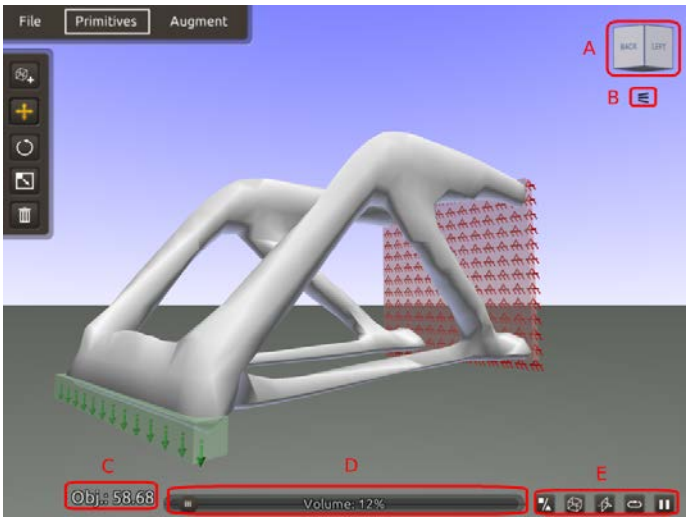


Figure 1: The main screen of the TopOpt 3D app. The red boxes mark the information and menus which are always present in the GUI.

1.1 Menus, start screen and options

Figure 1 shows the start screen for the TopOpt 3D app, where the red boxes are used to indicate the items and options that are always present in the GUI. In the following each of these items will be explained

A: The ViewCube – click on this and move the mouse/ngers to rotate the design.

B: Toggle between othographic and perspective view of the design.

C: Objective function - shows the current objective value for the design.

D: Volume fraction slider. Change the amount of material that can be used.

E: The five symbols in box E corresponds to the following actions:

- Toggle between marching cubes and voxel representation.
- Show/hide bounding box for the design domain.
- Show/hide mirroring of the design (see more in section 1.4).
- Restart the current optimization problem with a uniform initial design.
- Pause/start the optimization process.

The three menu items in the top left corner, i.e. file,. primitives and augment are explained in the upcomming sections.

1.2 File Menu

The fille menu is where the user can perform overall modications to the setup and get general information on the app.

New model – reset the design problem and starts the default example.

Configuration menu – see below.

About the app and general information on licensing, etc.

Export the design as an .obj file for 3D printing.

Pressing the configuration tool leads to the following drop menu. Here you can change the visualization threshold for the voxel and marching cubes representations, change domain aspect ratio, choose between coarse or fine finite element mesh and adjust the filter radius for the sensitivity filter.

Figure 2: The drop down file menu and the configuration box.

1.3 Primitives menu

The primitives menu is the place where the geometry can be modified and new geometric entities added to the design space.

Within the context of the TopOpt 3D app the primitives are the all geometric entities except for the optimized design. For example, in figure 3 the primitives are the red support wall and the green load domain.

Insert new primitive. Choose between spheres, boxes and plates.

Move. Mark this tool and click on a primitive to move it around. Note that movements are restricted to one direction at the time.

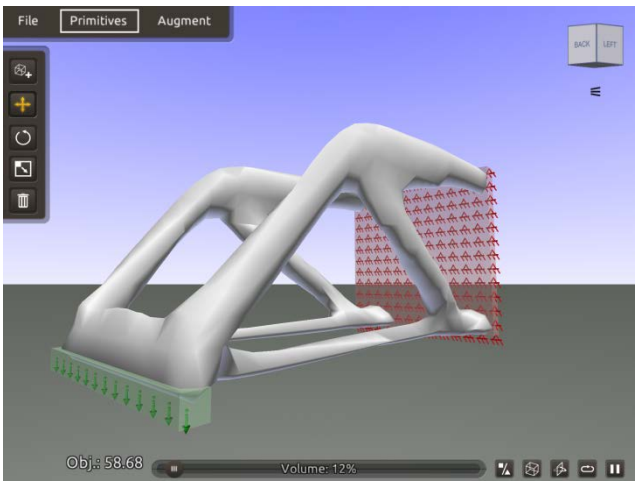


Figure 3: The primitive tools for interacting with the geometric entities.

Rotate. Mark this tool and click on a primitive to rotate it around one of the three major axis. Note that only one rotation is possible at the time and that the rotation is in steps of 22:5.

Scale. Mark this tool and click on a primitive to scale it along one of the three major axis.

Delete. Mark this tool and click on a primitive you wish to delete.

1.4 Augment menu

The augment menu is the place to add physical properties to the geometric primitives and to make mirror visualization possible if symmetry conditions are used. Note that the symmetry menu is purely visualization, and it is up to user to apply the correct symmetry boundary conditions. The augment menu and the symmtry visualization menu are shown in gure 1.4, left and right respectively. The seven entries in the augment menu are used for the following purposes:

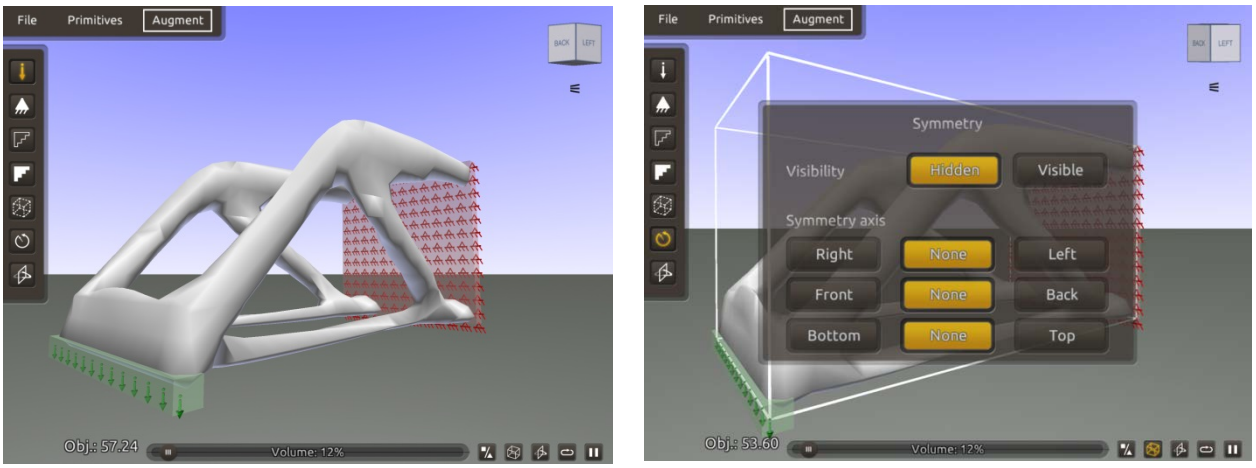


Figure 4: The augment menu with tools (left) and the symmetry settings (right)

Loading. Mark this tool and click on a primitive to assign a load. The load will be distributed onto the nodes inside the primitive and an element layer of xed solid elements is added for stability of the method. This tool also allows you to scale the load. The default load magnitude is 1 and assigned such that the combined distributed load for the given primitive is unity.

Support. Mark this tool and click on a primitive to assign a support. The default is to constrain all three spatial movements, but you can also use the tool to modify this such that e.g. only the x-direction is constrained.

 **Void**. Assign a (passive) void to a primitive, i.e. enforce that the primitive becomes a hole in the optimized design.

 **Solid**. Assign a (passive) solid to a primitive, i.e. enforce that the primitive becomes a xed solid region in the optimized design.

 **Clear**. Mark this tool and click on a primitive to clear the augmentation.

 **Rotate**. Mark this tool and click on a load to rotate it in space.

 **Symmetry**. The symmetry menu is used for visualizing symmetry conditions. Note that the corresponding symmetry boundary conditions are to be applied by the user, and that this tool is only for visualization purposes. The menu consists of the following two items, c.f. figure 4 (right)

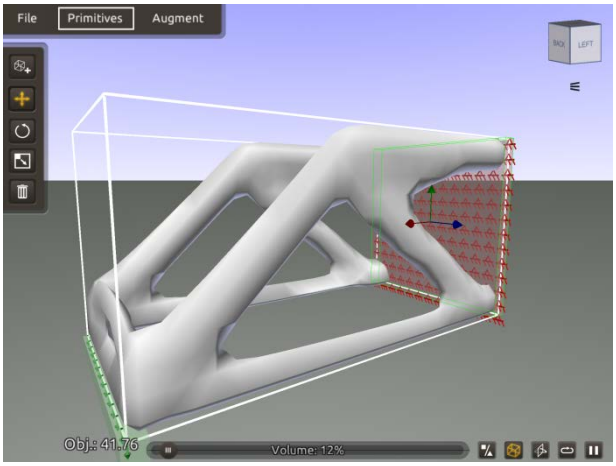
- Toggle symmetry visualization on and o.
- Choose which symmetry planes to be used for visualization.

2 Tutorials

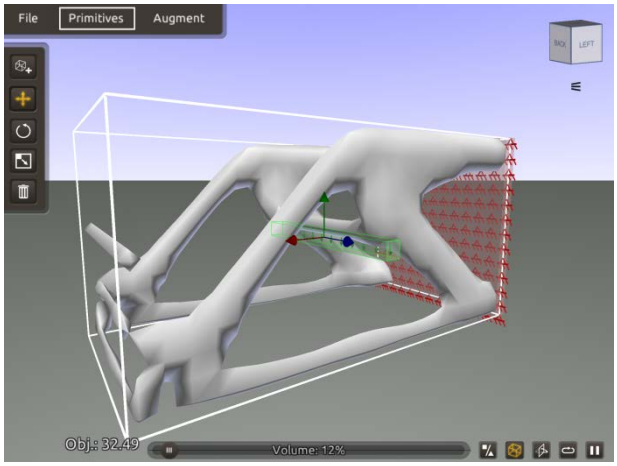
This part of the TopOpt3D user guide presents a few simple examples of usage. Please use these examples for inspiration.

2.1 Bridge design.

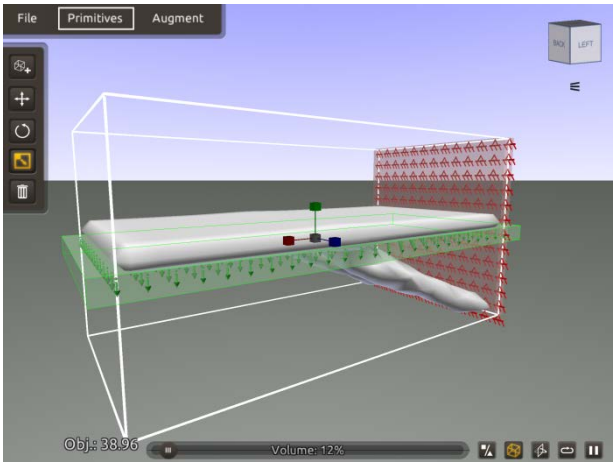
The design of a bridge is easily done using TopOpt3D. This tutorial will guide you from the start problem and all the way to a bridge design ready for export and printing. The procedure is explained chronologically with words and images below.



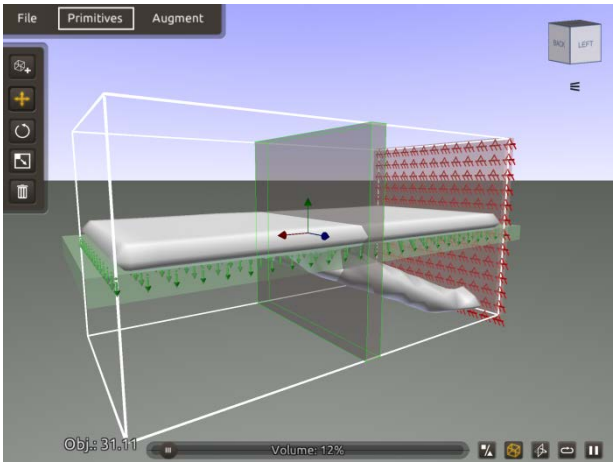
Step 1: Start the app and press the bounding box toggle.



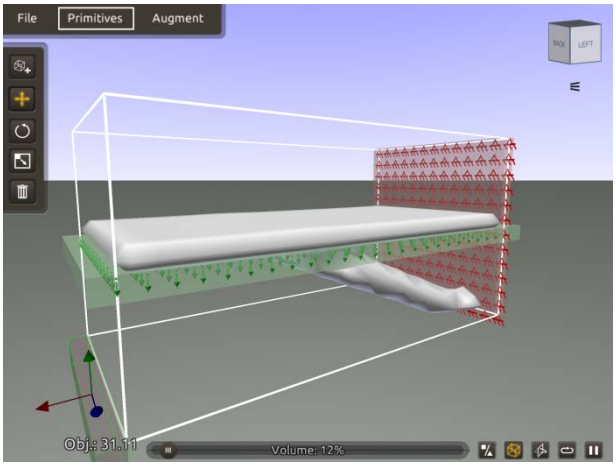
Step 2: Move the load to the center of the domain.



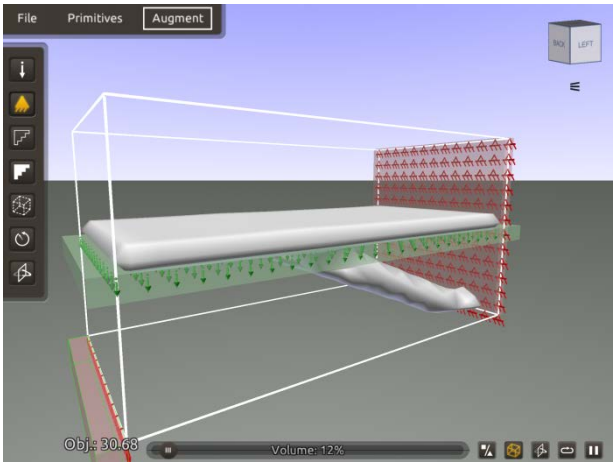
Step 3: Scale the load primitive along the red axis untill it covers the entire length of the design domain.



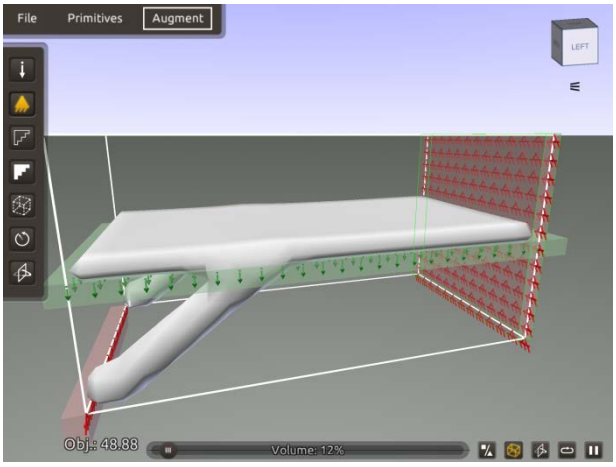
Step 4: Add a new primitive plate to the design problem



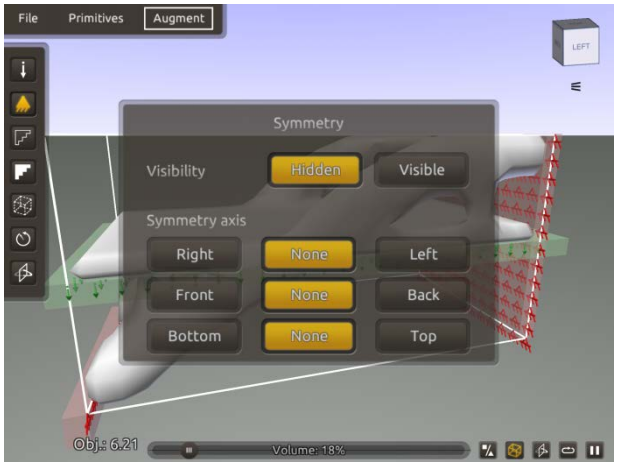
Step 5: Scale the new plate to a thin bar and move it to the lower left corner, i.e. where the load was originally situated



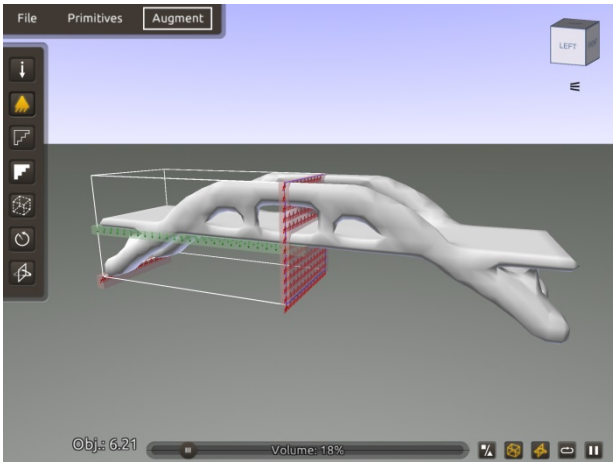
Step 6: Augment the new primitive with a support and let it be fixed in all directions



Step 7: Now we apply a symmetry condition to the wall-support (ViewCube -front). Mark the Augment-Support tool and click on the wall. Remove constraints on y and z (green and blue)



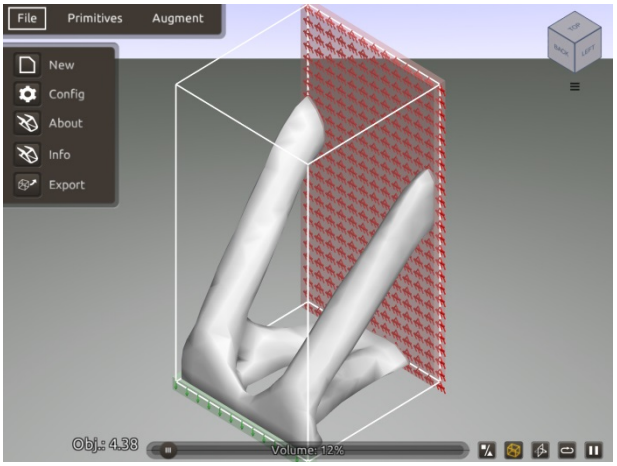
Step 8: Increase the volume fraction to 18%. The final step is to visualize the full design. Click on the Augment - Symmetry tool and choose Front as a symmetry plane.



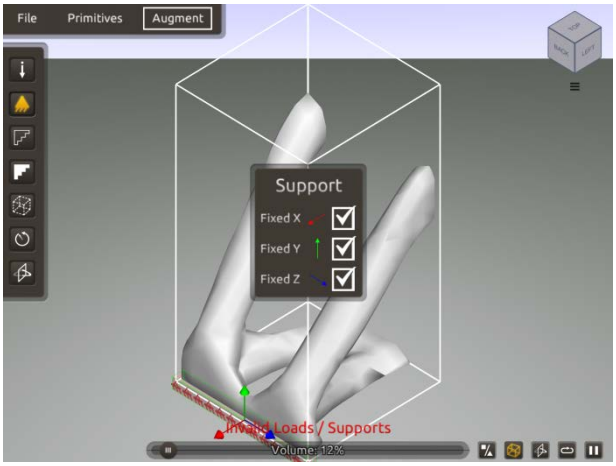
Step 9: You can now play around with moving the left support back and forth, moving the load primitive up and down, etc. in order to obtain dierent versions of a bridge

2.2 Chair design.

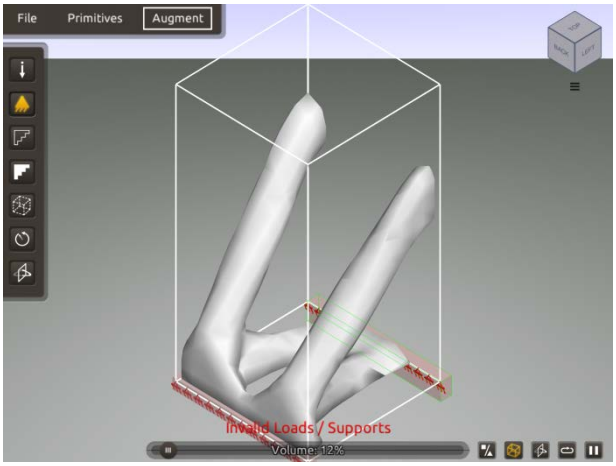
This tutorial is intended as inspiration on how to design a chair with the TopOpt app.



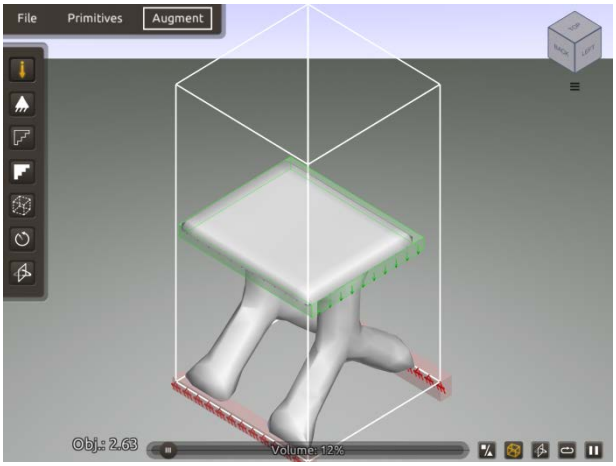
Step 1: Go to the file menu, choose Config and change the aspect ratio to 1x2x1. For a better overview choose orthographic visualization mode.



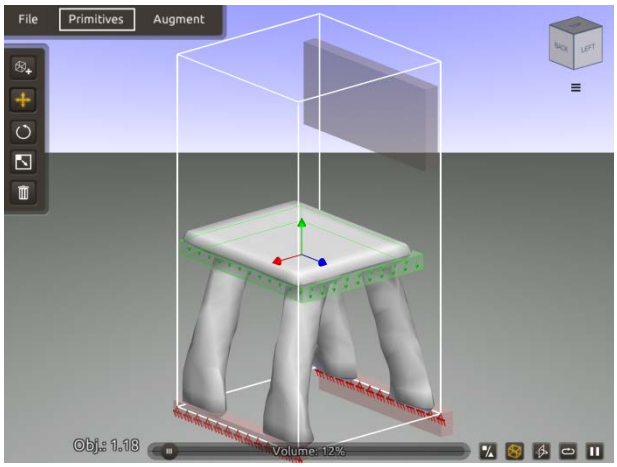
Step 2: Delete the wall primitive and augment the load primitive as a support fixed in all directions



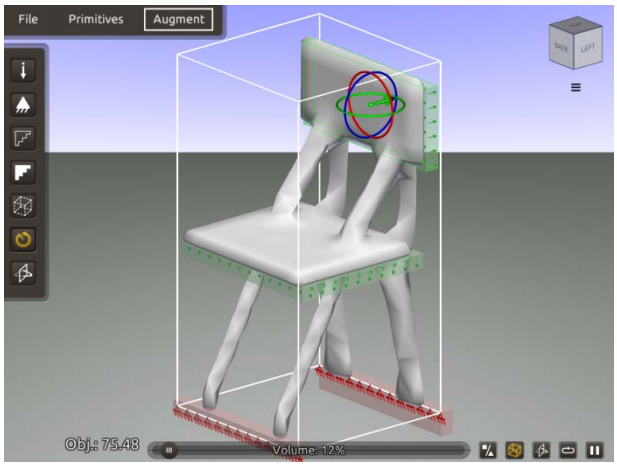
Step 3: Add a new primitive (plate) and scale it to a thin rectangle and move it to the bottom right corner (front face). Then augment it as a support (fully clamped).



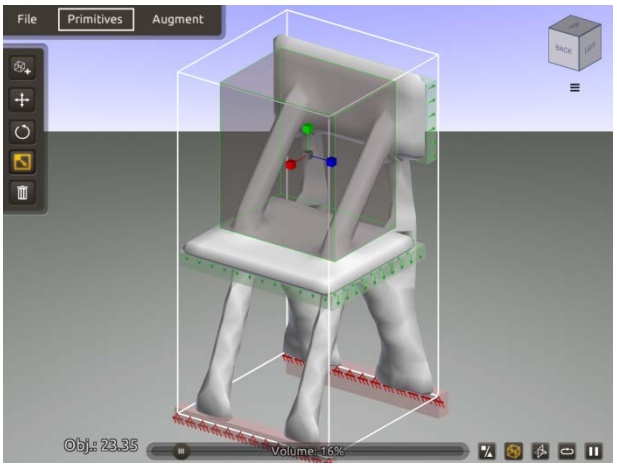
Step 4: Add another primitive (plate) and move, scale and rotate it untill it resembles the seat of the chair. Then augment it with a load.

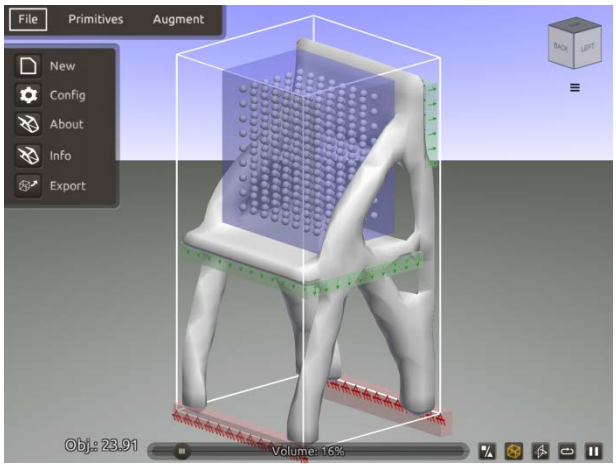


Step 5: Add a third primitive plate to the design domain. Move, scale and rotate the plate untill it resembles the back of the chair.

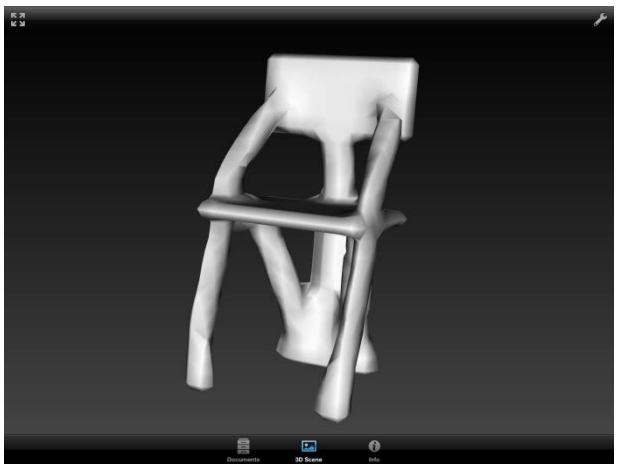


Step 6: Augment the back as load and rotate the load such that it points backwards.





Step 7: To get rid of the bars on the seat we will add a passive void domain. For this we add a primitive box and scale it accordingly. Then augment it as a passive void region and adjust the volume fraction to 16%.



Step 8: You can now export the design, or modify the supports, loads, etc. to obtain new and interesting chair designs. (Use KiwiViewer, Netfabb basic, etc)

3 References

[1] N. Aage, M.N. Jørgensen, C.S. Andreasen and O. Sigmund. Interactive topology optimization on hand-held devices, Struct Multidisc Optim, online first, 2012. (Uncorrected version available here.)

[2] M.P. Bendsøe and O. Sigmund. Topology Optimization; Theory, Methods and Applications. Springer Verlag Berlin Heidelberg New York, 2nd edition, 2004.

[3] O. Sigmund. A 99 line topology optimization code written in MATLAB, Struct Multidisc Optim, 21(2):120-127, 2001.

[4] E. Andreassen, A. Clausen, M. Schevenels, B. S. Lazarov and O. Sigmund. Efficient topology optimization in MATLAB using 88 lines of code, Struct Multidisc Optim,43:1-16, 2010.