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The BioAssemblyBot® is subject to U.S. Patent No. 9,910,935 (2018). BioBot® is subject to a patent pending filed by Advanced Solutions Life Sciences, LLC with the U.S Patent Office.

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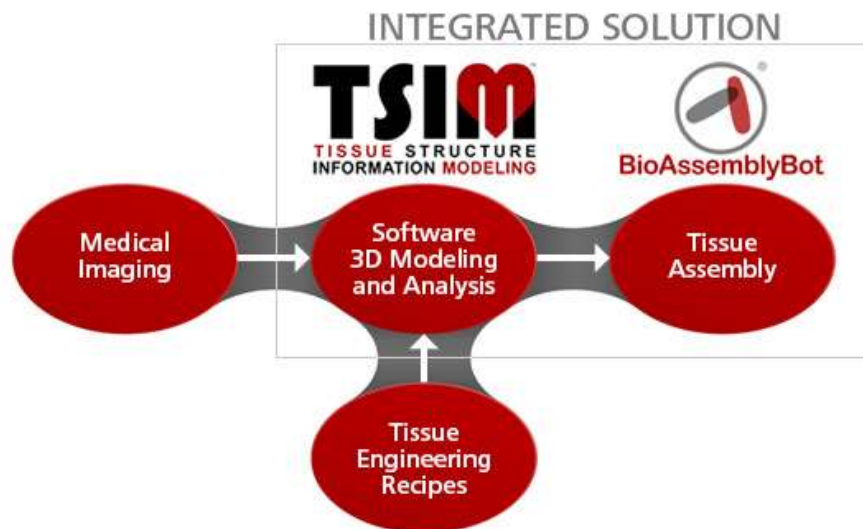
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About Tissue Structure Information Modeling (TSIM®)

TSIM® is an intuitive software tool that empowers doctors and scientists to design, visualize, simulate and analyze 3D computer models of complex tissue structures. TSIM® provides a comprehensive platform including medical imaging analysis, biological construct modeling, physical simulation, and fabrication. Starting with industry standard data (e.g. medical imaging), TSIM® guides users through the construction of a biological model capable of being simulated, analyzed, and fabricated.

Coupled with the [BioAssemblyBot®](#) or the BioBot® Basic, TSIM® provides a comprehensive integrated software and hardware technology platform to model and print 3D tissue structures.

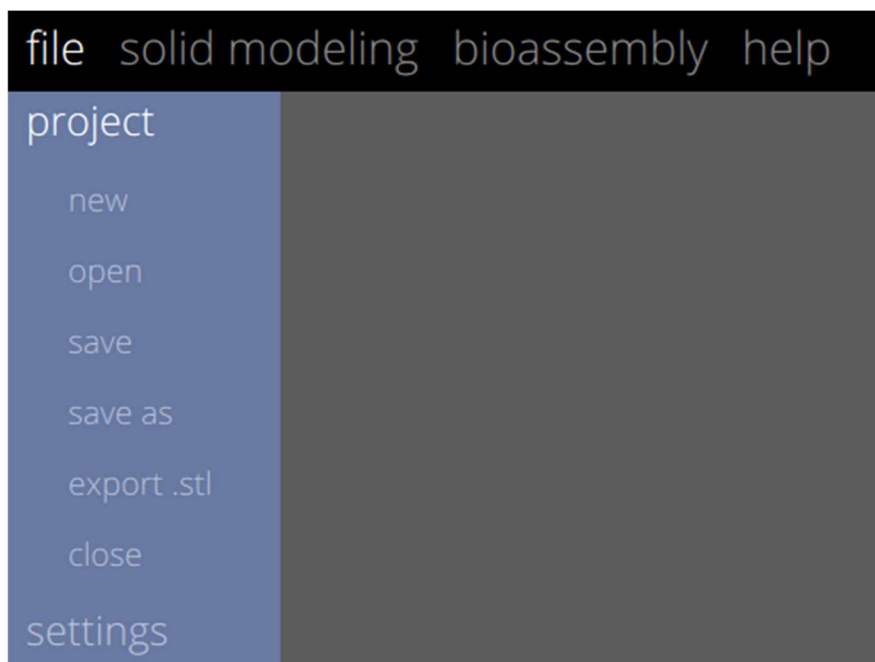
BioAssemblyBot® is an integrated tabletop workstation with a multi-axis robot that facilitates 3D tissue printing of composite geometric objects. The multi-axis robot design is the next stage of evolution in 3D printing technology and is well suited for the surgical precision required to assemble functional tissue structures.



BioBot® Basic is a benchtop workstation with a unique polar coordinate printing robot. Like the BioAssemblyBot®, it automatically handles material changes and pressure changes during a print. It allows printing of structures in up to 5 materials, and features two swappable stages.

File

The File screen allows a user to create a new model, open, or save an existing TSIM® project file, and enter necessary settings related to the BioAssemblyBot or Camera.



New

Creates a new TSIM® project. The user will need to select a file location and enter a name for the project.

Open

Open existing .tsim project files.

Save or Save As

Saves project files in a desired location. Saving creates a .tsim file.

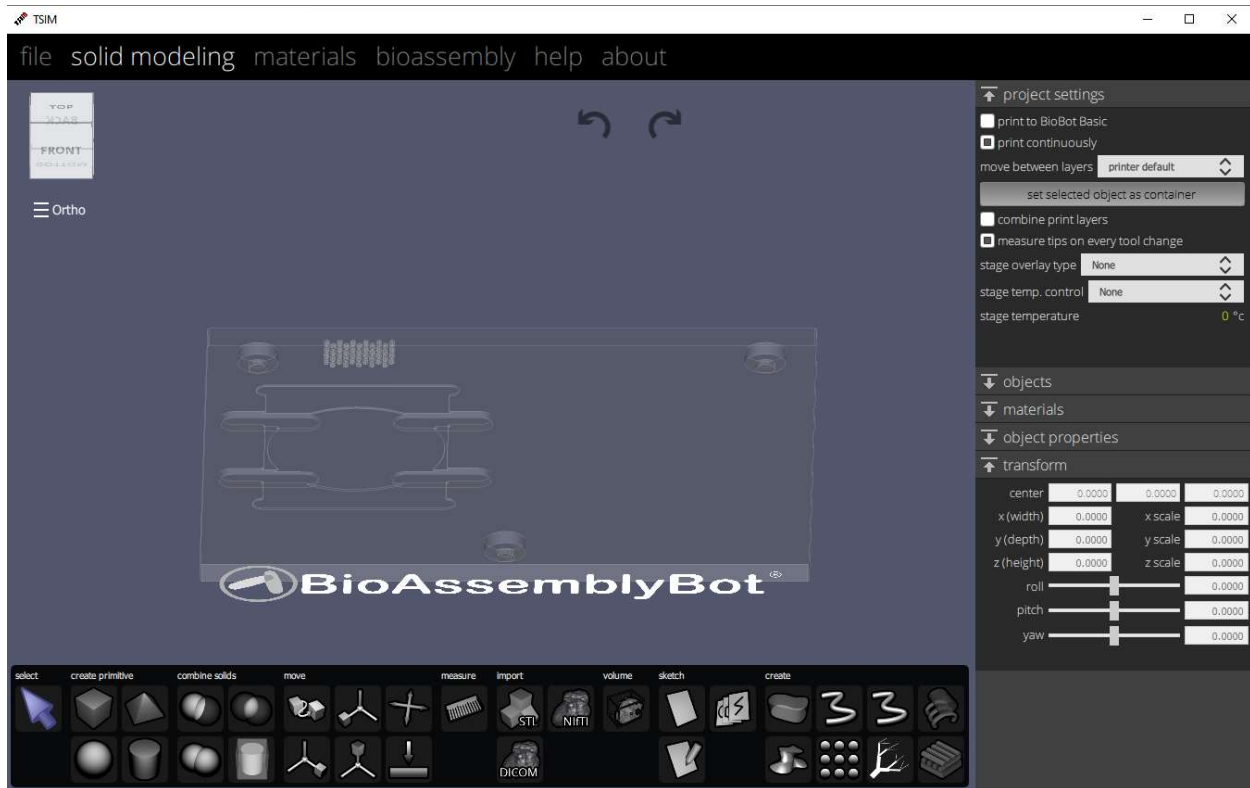
Settings



bio assembly bot network address – These settings are only used for entering IP address or machine name of the BioAssemblyBot HMI. This allows a connection between TSIM and the BioAssemblyBot. Once the correct IP/machine name is entered, the user should click *Accept*. The BioAssemblyBot at this IP/machine will be reviewed, and if found, *connected to bio assembly bot* text will appear against a green background. If the IP/machine name is not found on the network, *connection to bio assembly bot failed* text will appear against a red background. Please review network settings and IP/machine name, and retry as necessary if this occurs. Camera framerate and exposure will allow you to change the streaming camera settings for the camera connected to the BAB.

External slicer path ('Slic3r-console.exe') – If you chose to use Slic3r to slice the print path and use in-fill patterning, you can download the Slic3r program using the link in the settings dialog. After you install it, put the path to the Slic3r console and this option will be enabled.

Solid Modeling



The **Solid Modeling** screen provides a 3D environment in which a user can create models or import existing models in a variety of standard imaging formats, such as STL, DICOM and NIfTI formats. Once imported, the models can be used for printing on the BAB. Complex models may be created using the basic set of geometric objects (box, cylinder, sphere and pyramid). Tools are also provided (combine, align, sketch, volume and surface) to further manipulate models.



The ability to undo or redo an action is made available via the two arrows in the top center of the Solid Modeling screen.

The display above shows the BioAssemblyBot® stage. To change to the BioBot® Basic stage, click the “print to BioBot Basic” checkbox in the top right of the screen.

3D viewing perspective basics

Pan: hold down the scroll wheel or press the alt key and move the mouse

Rotate:

- Hold the SHIFT key, left click, hold, and move the mouse
- Left click the View cube, hold, and move the mouse
- Click a specific face of the View cube (top, bottom, front, back, right and left)

Zoom in and out:



- Scroll the mouse wheel
- Right click, hold, and move the mouse

To return to the default view	~
Horizontal view	1 OR F2
Left horizontal view	2 OR F3
Overhead view	3 OR F4

Orthographic / Perspective View

Orthographic – is a means of representing a three-dimensional object in two dimensions.

Perspective – is an approximate representation of an image as it is seen by the eye.



TSIM Panel

The **TSIM Panel** is divided into groups. Each group contains specific tools.



The groups and tools within are:

Select: Selection of created objects.

Create Primitive: Creation of simple solid objects.

Combine Solids: Combining solid objects into more complex solid objects.

Move: Movement, alignment, and precise placement of objects within the build space.

Measure: Individual measurements of objects, edges, and faces.

Import: Allow 3D volumetric or polygonal datasets to be imported.

Volume: Allow review and modification of 3D volumetric datasets

Sketch: Creation and modification of 2D sketches, which can become complex solid objects.

Create: Custom tools to create complex 3D objects, or sets of complex 3D objects.

Select Tools



The **Select Solids** tool is the default tool. Selecting an object will highlight the object, surround the object with [interaction widgets](#), and open the [Object Menu](#) on the right-hand side of the screen.

To select multiple objects, hold down the CTRL key, then left click each desired object.

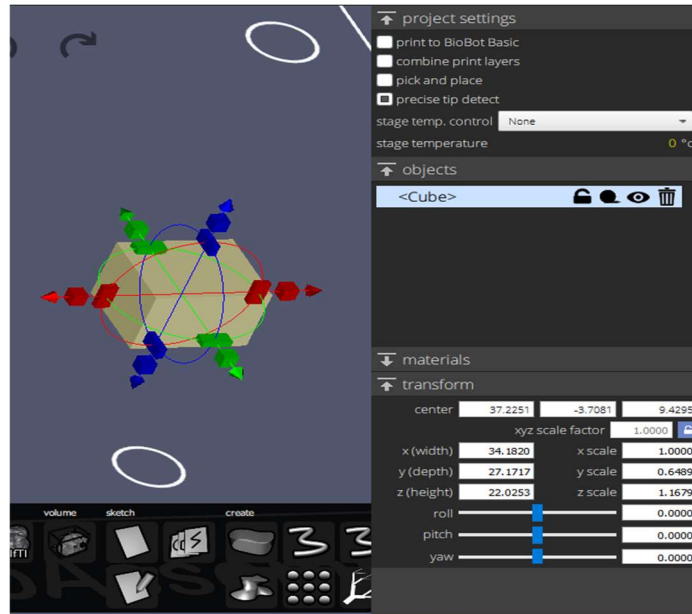


Figure 1: The selected box is highlighted with a yellow tint, and the object name is highlighted in blue in the Object menu.

Interaction Widgets

The interaction widgets can be used to translate, rotate, and scale the object in the X, Y, and Z axes.

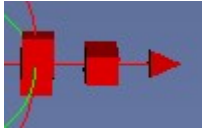


Figure 1: X axis interaction widget

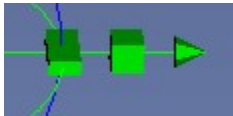


Figure 2: Y axis interaction widget

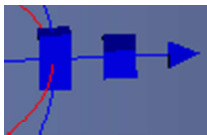


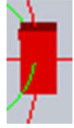
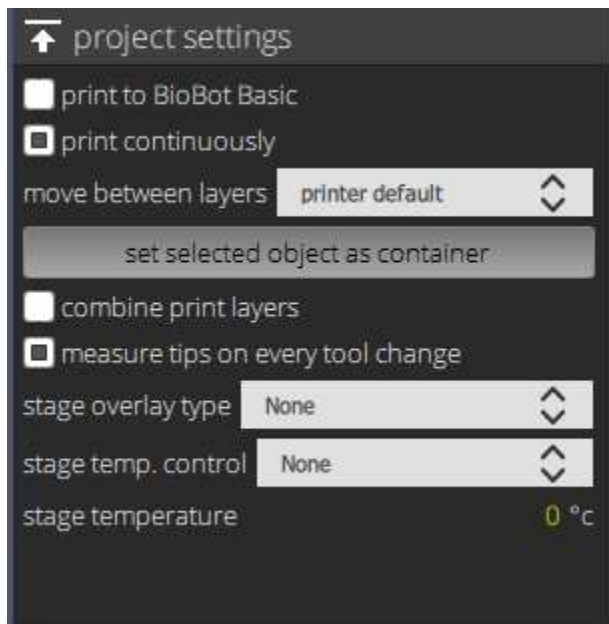


Figure 3: Z axis interaction widget

- Move an object: Left click the arrow, hold down, and move the mouse.  (For more ways to move an object, see [Transform Selection](#) and [Move Tools](#))
- Scale an object: Left click the center cube, hold down, and move the mouse.  (To lock the aspect ratio, see [Transform Selection](#))
- Rotate an object: Left click the large, rectangular block, hold down, and move the mouse. 

Project Settings Menu

The Project Settings Menu allows you to choose global options which will affect your print.



Print to BioBot Basic – With this selected, the *Solid Modeling* screen is altered so it reflects the BioBot® Basic stage, rather than the BioAssemblyBot® stage.

Print Continuously – With this selected, the print time required for a mesh print will be reduced by approximately 10%. It combines pathing in a z-slice into a single path for the BioAssemblyBot® or BioBot® to follow. This is left on as a default.

Move between print layers

.mat line height – Moves to the next layer without picking up. If you are using a well plate, this option is not desirable as it may impact the plate wall when moving between objects, but this is the fastest print option.

Above container – This allows you to select a container model to set the move up height. This will prevent collisions if you are printing in a container such as a well plate.

Printer default – This is the printer default. Consult support to see how your unit is configured.

Combine Print Layers – With this selected, the BioAssemblyBot® or BioBot® Basic will print objects in a Concurrent fashion, where each object will be completed before the next is started. Default is off, which prints objects in a Sequential, or layer by layer, fashion.

Measure tips on every tool change – With this selected, the BioAssemblyBot® will measure the tool tip location each time a tool is changed. If it is disabled, tip measurement will only be done one per tool for a single print. This can save a lot of time if your print is changing materials often, but it may not be as precise.

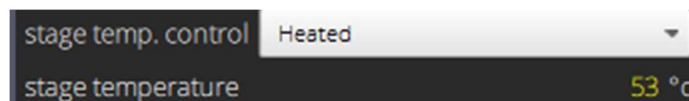
Stage Overlay Type – Useful only on BioBot® Basics. Choosing an overlay type will show the stage overlay on the BioBot Basic stage in the *Solid Modeling* screen.

Stage Temperature Control – Useful only on BioAssemblyBots® which are equipped with a stage capable of heating or cooling. Set this to Heated to heat the stage, Cooled to cool the stage, or None to leave the stage alone for an Ambient print.

Stage Temperature – The BioAssemblyBot® must be equipped with a stage capable of heating or cooling. This can be set to a value between 10-60 degrees Celsius.

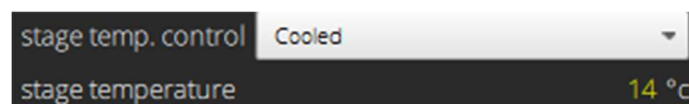
Example:

To heat the stage, set *Stage Temp. Control* to Heated, and choose a temperature in the range of [your current ambient – 60 C] for *Stage Temperature*.



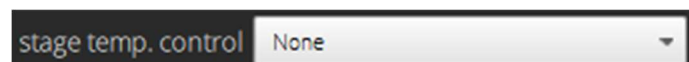
Example:

To cool the stage, set *Stage Temp. Control* to Cooled, and choose a temperature in the range of [10 C – your current ambient] for *Stage Temperature*.



Example:

To return the stage to an Ambient stage, set *Stage Temp. Control* to None. The value in *Stage Temperature*, if any is set, will be ignored.



Objects Menu

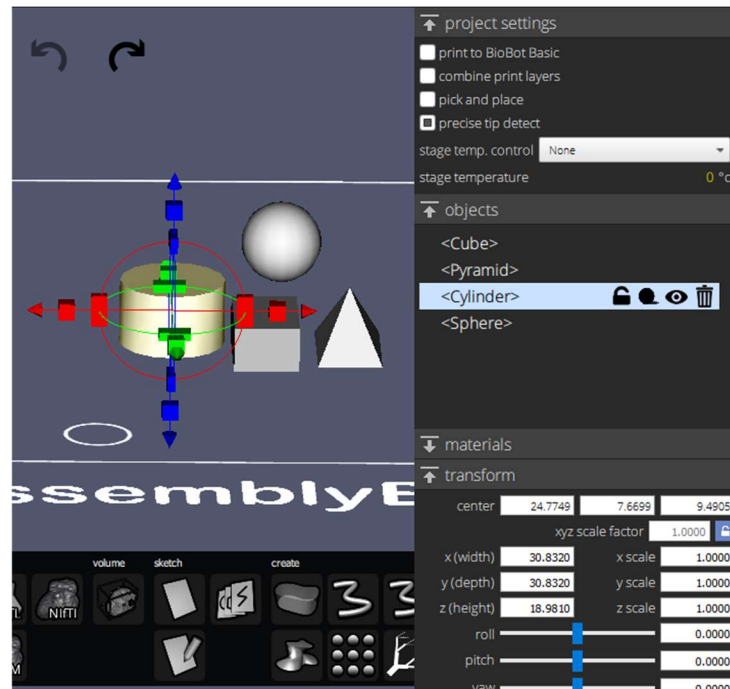


Figure 1: The Objects menu is displayed on the right side after selecting an object

Select an object to display the Objects Menu. This menu contains the **Objects List**, **Object Properties**, **Material Selection**, and **Transform Selection**.

Objects List

The Objects List is a comprehensive list of the objects in the current model. As objects are added to the modeling environment, the Objects List will update. See the above figure where four objects have been added (Cube, Pyramid, Cylinder and Sphere) and each are displayed in the Objects List. When these four objects are printed in the BioAssemblyBot®, they will be printed from the first object in the list to the last.

The selected object in the objects list has additional options available. For example, with the cylinder selected, there are options to:



Lock the physical attributes of the object, preventing it from being moved, scaled, or rotated.



Make the object transparent



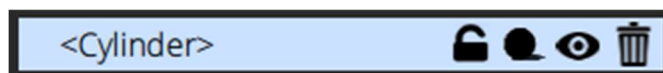
Delete the object from the modeling environment.



Hide (or unhide) the object.

Object Properties (Renaming an object)

The default name of any object is the type of object. It may be helpful to assign more meaningful names to each object. Renaming an object can be achieved by clicking on the name of the object. This will allow you to rename the object.



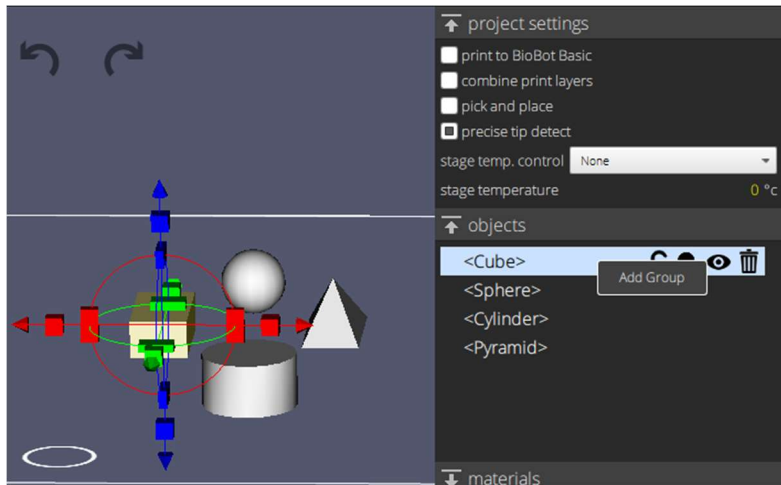
to



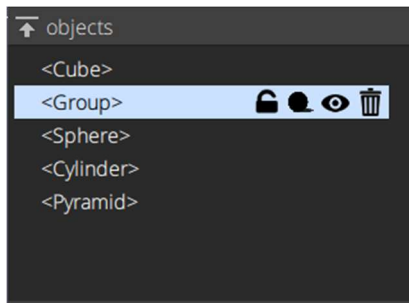
Grouping

Grouping – is the process of arranging 2 or more objects together in a group or groups.

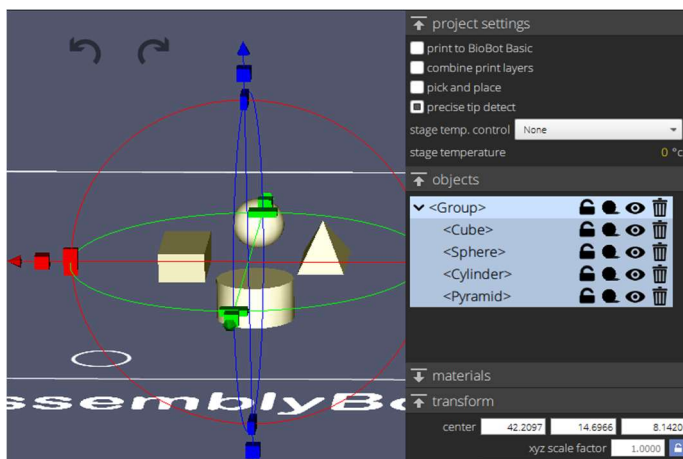
To add a group, right click in the Objects menu, then choose “Add Group” from the popup.



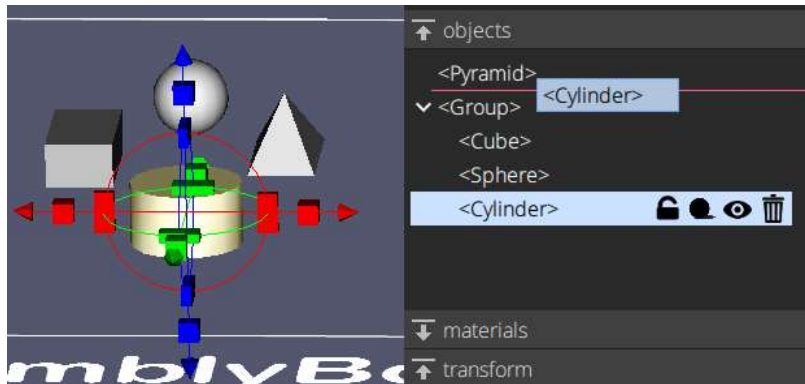
This will create a group with the name of <Group>.



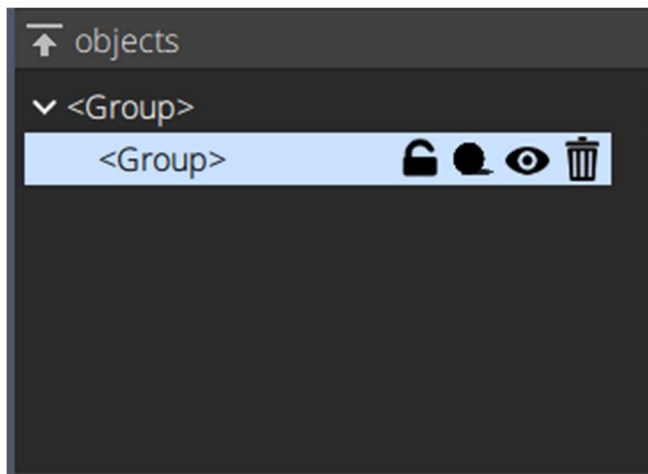
To add objects to a group, in the Objects menu, drag and drop the desired objects into the newly created group. This will indent the names of the objects in the group.



To remove objects from a group, in the Objects menu, drag and drop the desired objects from the group to a position outside of the group.



To add a group to another group, in the Objects menu, drag and drop the group into another group to combine the two. This will create a subgroup.

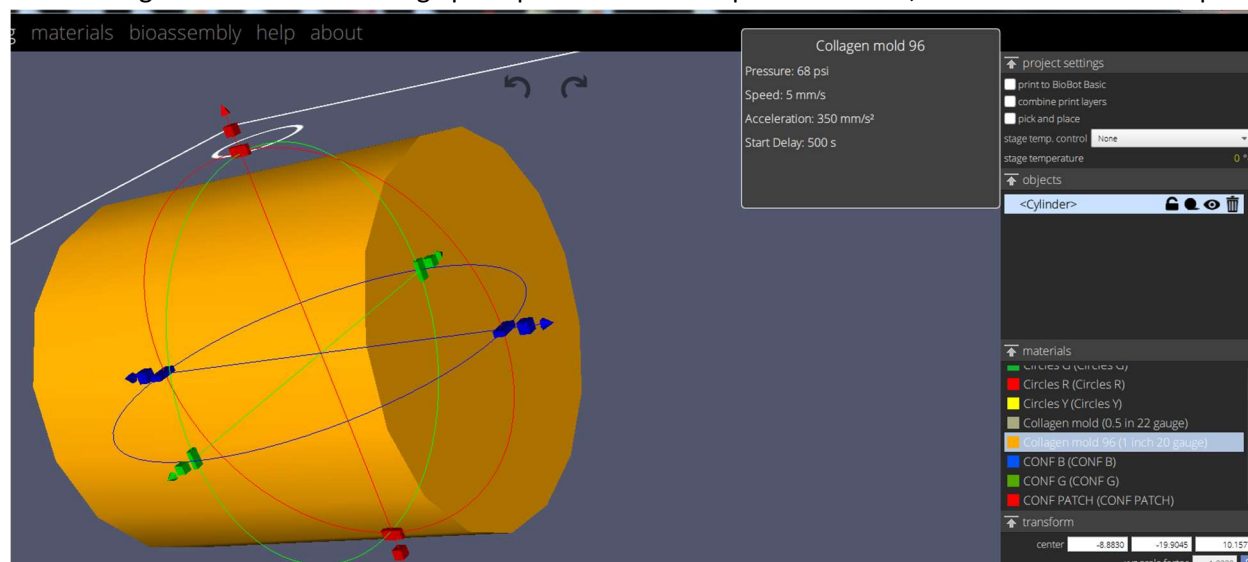


Material Selection

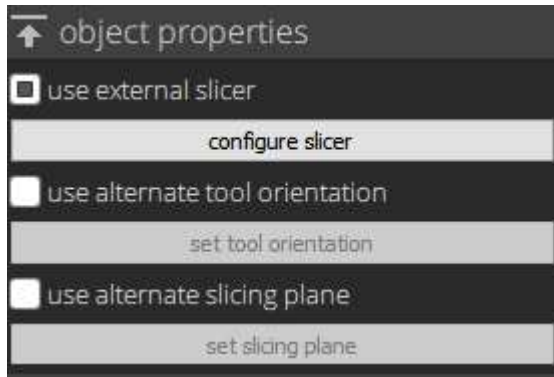
In order for the BioAssemblyBot® or BioBot® Basic to print any object, there must be a material assigned to the object in TSIM®. Assign materials by selecting an object and choosing one of the options from the **Material Selection** section in the **Objects** menu.

Hover over a material in **Material Selection** to display details. This will show the material name, pressure, speed, acceleration, and start delay. To open the Material Table, click Edit Material Table or right click a material and click Edit Material.

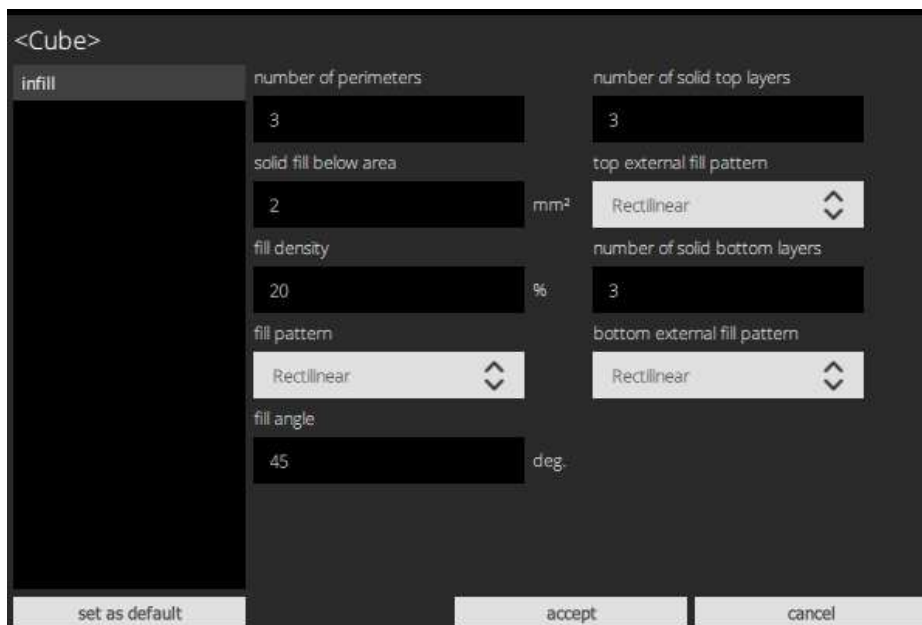
Left-clicking on a material will bring up the parameters in a separate window, viewable in the 3D viewport.



Object Properties



Use External Slicer – This option allows you to use Slic3r to do in-fill patterning. Select an object, check the box, and click configure slicer to configure the slicing parameters.



- Number of perimeters – This is the number of solid lines printed on the outside of the object (shell).
- Solid fill area below – This is the area in which no infill pattern is used on the bottom of the object.
- Fill density – the infill pattern density.
- Fill pattern – the pattern type to use for infill
- Fill angle – angle in which the pattern is applied
- Number of solid top layers – number of solid layers at the top of the object with no infill.
- Top/bottom external fill pattern – external infill pattern.

Use alternate tool orientation – (6 axis printers only) – This option allows you to select a face on an existing model to set its tool orientation for printing allowing the tool head to be in a non z-facing direction.

Use alternate slicing plane– (6 axis printers only) – This will allow you to select a face as a plane to slice an object. Layers will orient in the direction of the selected face (face as bottom plane).

Transform Selection

The **Transform Selection** panel is shown in the bottom right of the application.

Move an object: Change the x (width), y (depth) or z (height) values.

Scale an object:

- Change the xyz scale factor as a single value to scale the object in x, y, and z simultaneously.
- Change the x scale, y scale, and z scale value to alter the size of the object by stretching or compressing it.



If the xyz scale factor is 'locked', the object will be scaled uniformly, or with a locked aspect ratio. Changing the xyz scale factor or any of the individual lengths will provide for uniform scaling in the other two axes.



If 'unlocked', scaling can be done along separately along the individual X, Y and Z scales.

Rotate an object: Drag either the individual roll, pitch or yaw sliders under the **Transform Selection** panel.

Create Tools

For all of the create tools, ESC and Enter cancel the creation. Clicking “create” in the tool menu finalizes the object in the chosen dimensions.

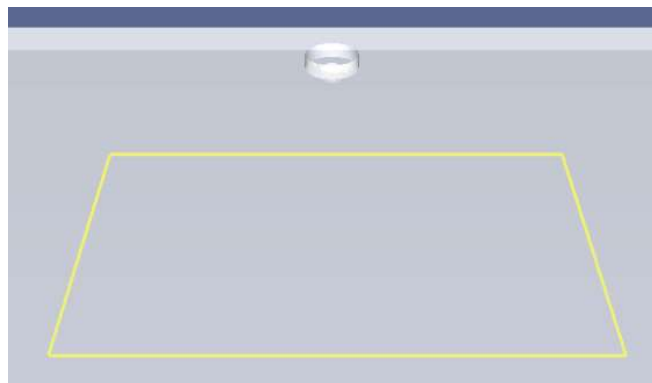
Create a Box



This tool allows you to create a simple box in the modeling environment. Also included is the ability to transform a selected box via interaction widgets located on the object, or by changing the respective property value under **Transform Selection**. These values include changing the center, scale and position of the box.

To add a box in the modeling environment

1. Click on the **Create a Box** icon.
2. Click the location on the modeling environment to begin placing the Box.
3. The size of the Box’s base can be adjusted by moving the mouse accordingly. To accept, click your left mouse button to set the base.



4. Moving the mouse vertically will allow you to set the height of the Box. To accept, click to set the height. Further refinements to the dimensions of the Box can be made by manually editing the width/depth/height of the object in the box menu on the right hand side.



5. To finalize the Box, click the **create** button in the box menu.

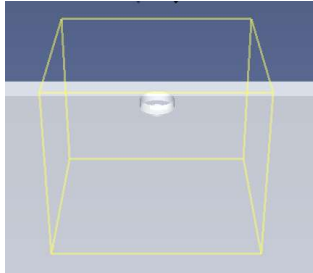


Figure 1: Setting the height of the Box

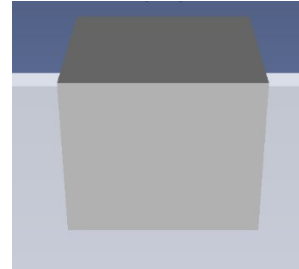
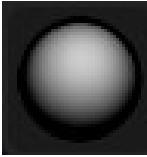


Figure 2: Final Box

Create a Sphere



This tool allows you to create a sphere in the modeling environment. Also included is the ability to transform a selected sphere via interaction widgets located on the object, or by changing the respective property value under **Transform Selection**. These values include changing the center, scale and position of the sphere.

To add a sphere in the modeling environment

1. Click on the **Create a Sphere** icon.
2. Click the location in the modeling environment on which to place the sphere.
3. The size of the sphere can be adjusted by moving your mouse. To set the size, click once more. You can further refine the sphere by manually entering the center's coordinates or changing the value of the radius.
4. To accept the final object, click the **Create Solid** button on the **Sphere** menu.

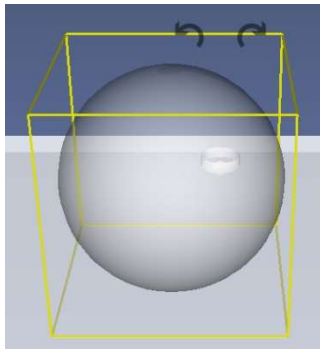


Figure 1: Scaling a sphere in the modeling environment

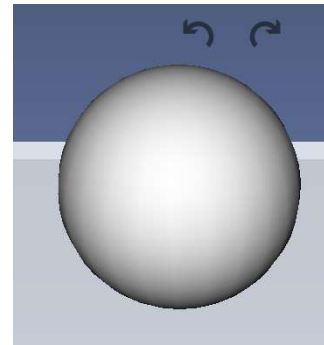


Figure 2: Final Sphere

Using the Cylinder Tool



This tool allows you to create a cylinder in the modeling environment. Also included is the ability to transform a selected cylinder via interaction widgets located on the object, or by changing the respective property value under **Transform Selection**. These values include changing the center, radius and height of the cylinder.

To add a Cylinder to the modeling environment:

1. Click on the **Create a Cylinder** icon.
2. Click the location in the modeling environment on which to place the cylinder.
3. The size of the cylinder's base can be adjusted by moving the mouse. To accept, click to set the base.

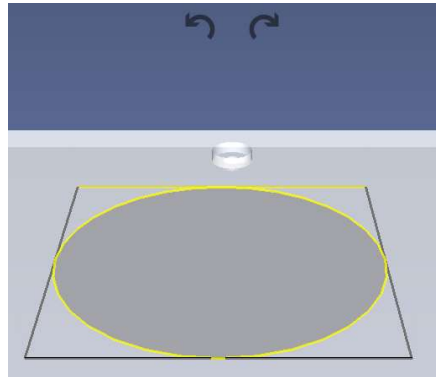


Figure 1: Setting the base of the cylinder

4. Next, adjust the height of the cylinder by moving your mouse and clicking once more to set it. You can further refine the dimensions of the cylinder by manually entering the center's coordinates or the value of the radius or the height.
5. To accept the final object, click the **Create Solid**.

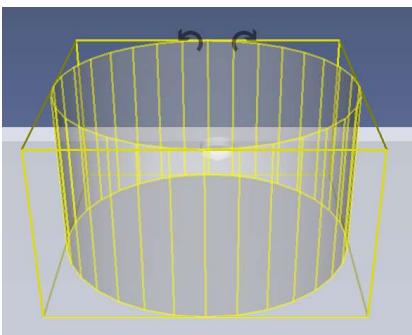


Figure 2: Setting the height of the cylinder

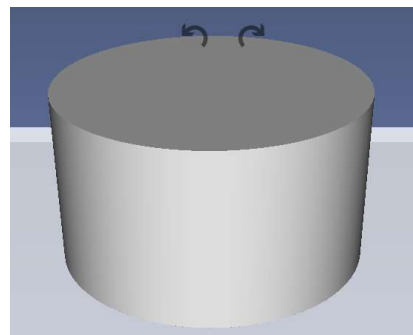


Figure 3: Final cylinder

Using the Pyramid Tool



This tool allows you to create a pyramid in the modeling environment. Also included is the ability to transform a selected pyramid via interaction widgets located on the object, or by changing the respective property value under **Transform Selection**. These values include changing the center, radius and height of the pyramid.

To add a Pyramid to the modeling environment:

1. Click on the Pyramid Tool icon.
2. Click the location in the modeling environment on which to place the pyramid.
3. The size of the pyramid's base can be adjusted by moving the mouse. To accept, click to set the base.

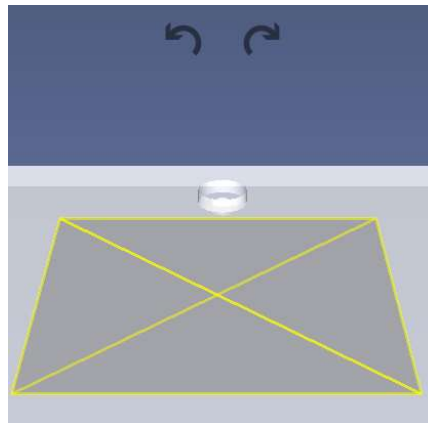


Figure 1: Setting the base of the pyramid

4. Next, set the height of the pyramid by moving your mouse. To accept, click to set the model. You can further refine the dimensions of the pyramid by manually entering the center's coordinates or the value of the radius or the height.
5. To accept the final object, click the **Create Solid**.

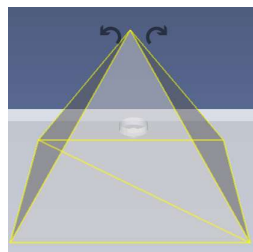


Figure 2: Setting the height of the pyramid

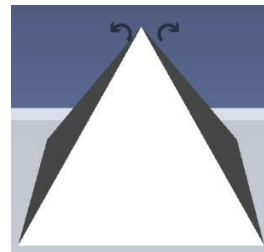


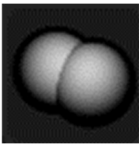
Figure 3: Final pyramid

Combine tools

As you build your desired objects, it will be necessary to build custom objects using a combination of the basic objects provided. The **Combine** tools allows you to perform a variety of operations, such as

- Add one solid to another
- Subtract one solid to another
- Intersect one solid to another

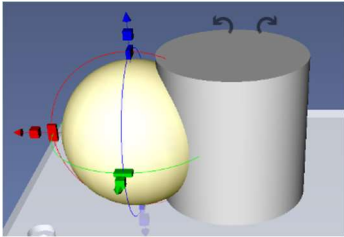
Add one solid to another



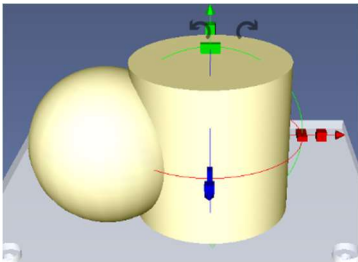
This tool is used to merge together two separate object volumes so that their boundaries will be defined as a single region.

To perform an Addition operation:

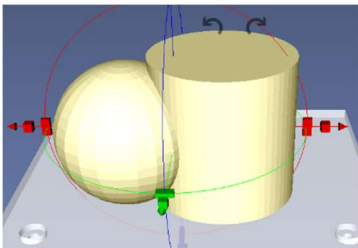
1. Click on the first object to select it.



2. Hold down the Ctrl key and click the second object.



3. Click the Addition icon to join the two objects. The region boundary will now encompass the newly unified object.



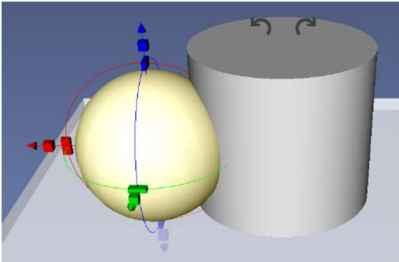
Difference



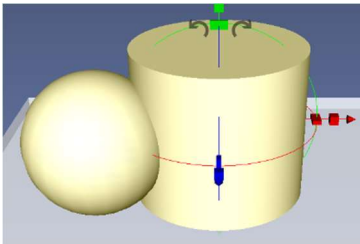
This tool is used to define a region boundary based on the subtraction of an actively selected object from an inactive object.

To perform a Difference operation:

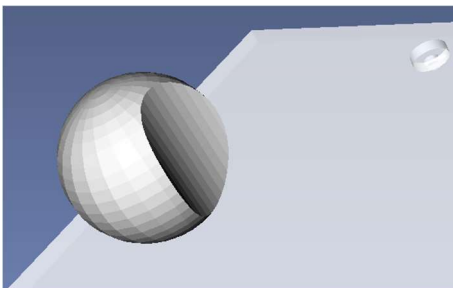
1. Click on the first object to select it.



2. Hold down the Ctrl key and click the second object.



3. Click the Difference icon to leave the portion of the active object that does not intersect with the inactive object.



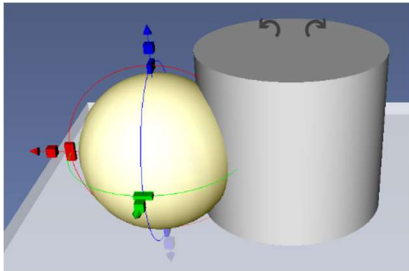
Intersection



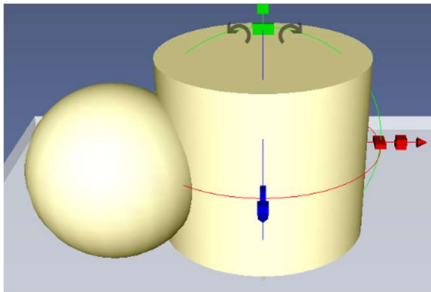
This tool is used to define a region boundary based on the intersection of two objects.

To perform an Intersection operation:

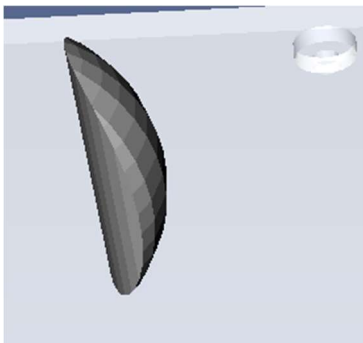
1. Click on the first object to select it.



2. Hold down the Ctrl key and click the second object.



3. Click the Intersection icon to leave the portion of the active object that intersects with both objects.



Move Tools

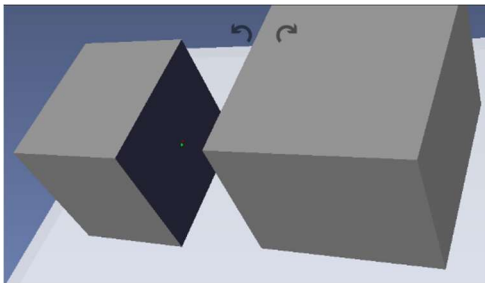
Align two faces on different objects



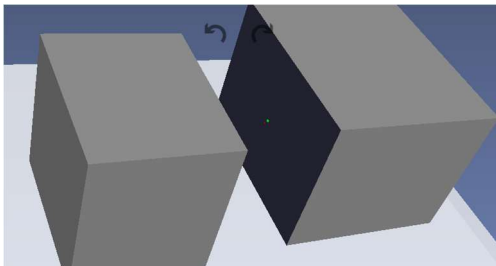
This align tool will allow you to bring together two objects, based on a point selected on each object. After the operation, you will still have the ability to select the individual objects.

Steps

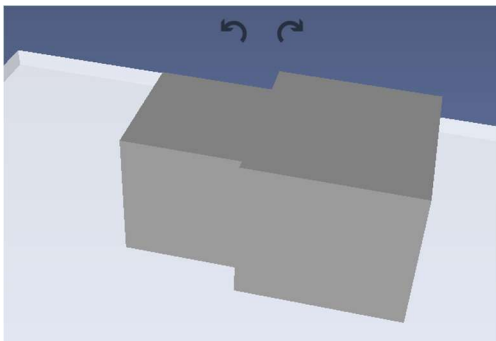
1. Click the Align two faces icon.
2. Select a point on the desired face on the first object. The face will be highlighted (as seen by the darker cube face in the image below). A red dot denotes the point of selection and when you move to the center a green dot will appear as well.



3. Now select the desired point on the face of the second object. You may rotate/zoom the camera view to precisely select the point.



4. The first object will move such that the two points on the selected faces will be aligned together.



Align center of one object to a point on another's y-axis

This tool allows you to align two different objects along the y-axis, based on their center points. After the operation, you will still have the ability to select the individual objects.

Steps

1. Click on a point on the first object. If you move to the center or corner of the face, the red dot will turn into a green dot to indicate that it is on a center or corner.
2. Click on a point on the second object.
3. The first object will move in the y-axis so that their centers line up accordingly.

Align center of one object to a point on another's x-axis

This tool allows you to align two different objects along the x-axis, based on their center points. After the operation, you will still have the ability to select the individual objects.

Steps

1. Click on a point on the first object.
2. Click on a point on the second object.
3. The first object will move in the x-axis so that their centers line up accordingly.

Align center of one object to a point on another's z-axis

This tool allows you to align two different objects along the z-axis, based on their center points. After the operation, you will still have the ability to select the individual objects.

Steps

1. Click on a point on the first object.
2. Click on a point on the second object.
3. The first object will move accordingly in the z-axis so that their centers line up accordingly.

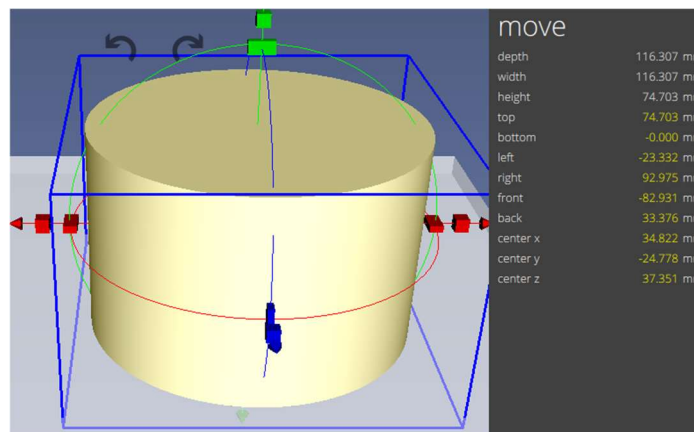
Drag



The drag tool allows you to move a selected object in different directions relative to the “ground”, which is determined based on your camera angle. For example, in the default view, dragging a model will move your object in the xy-plane.

Using the Drag Tool

1. Click on the Drag Tool.
2. Select the object to move. A blue frame will surround your selected object and the **Move** menu will be visible on the right hand side.



3. Drag the object by moving your mouse. The values contained in the **Move** menu will update, respective to the move. Alternatively, clicking on and manually editing any value in the **Move** menu will result in the object being moved by the specified amount.



Lay Flat



The Lay Flat tool allows you to align a selected face of a model to the platform or ‘ground plane’.

Steps to measure using the Lay Flat Tool

1. Click the Lay Flat Tool.
2. Select the desired face of the model, which is to be placed on the platform.
3. The model will now be oriented and placed on the platform.

Measure



This tool will allow you to draw point to point measurement lines on both the 2D image slices and within the 3D model. This will be useful when measuring the dimensions of the 3D model.

Steps to measure using the Measure Tool

1. Click the Measure Tool.
2. Click the starting point to begin measuring.
3. As you move your mouse towards an end point, the measurement is dynamically displayed in millimeters.
4. Clicking on the end point will affix the distance between the two spots.



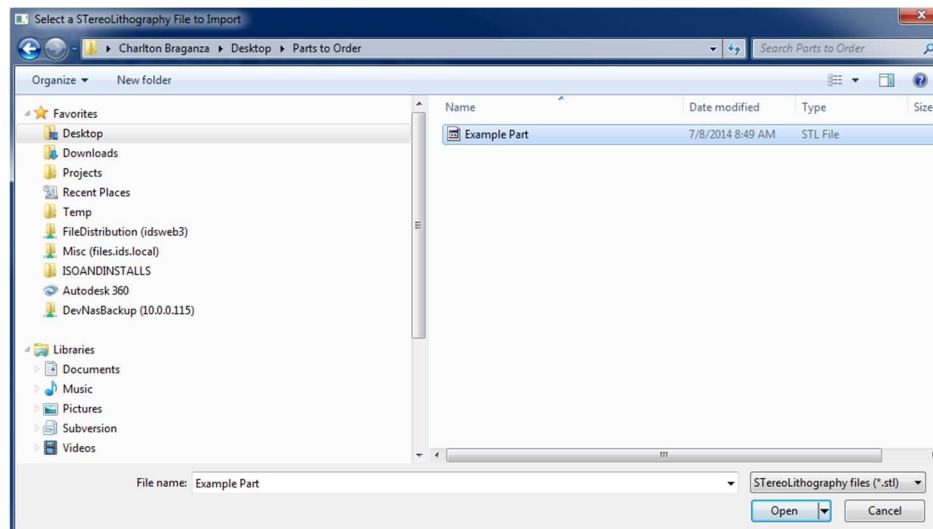
Importing a model file

Users may open existing model files created in external programs. Acceptable file formats include STL, NIfTI and DICOM. See “import” in the TSIM® Panel.

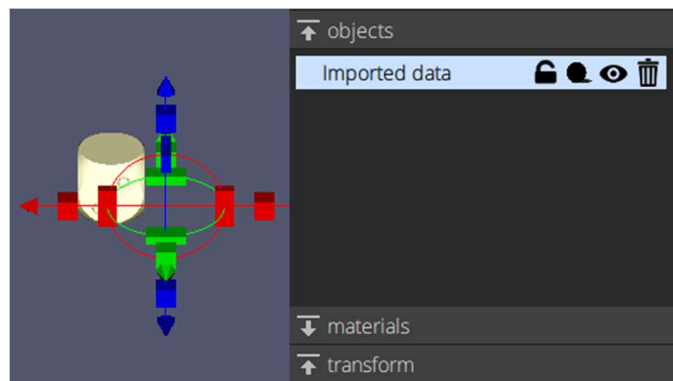


Importing an STL file into the modeling environment:

1. Click on the Import STL icon in the **Import** section.
2. Navigate to the folder containing the STL files.
3. Highlight the desired file and click the ‘Open’ button to import the model.



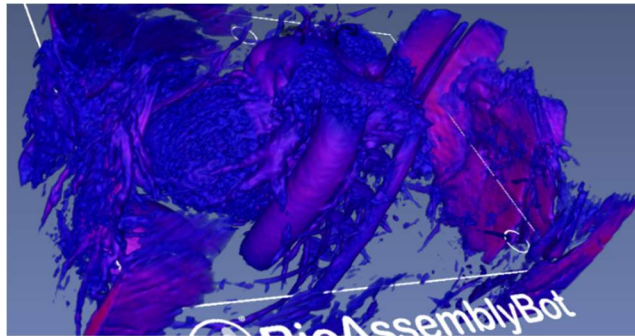
4. The object will appear in the modeling environment. As in the case of objects created in TSIM, you will have the ability to modify the imported object via the **Objects** menu on the right-hand side.





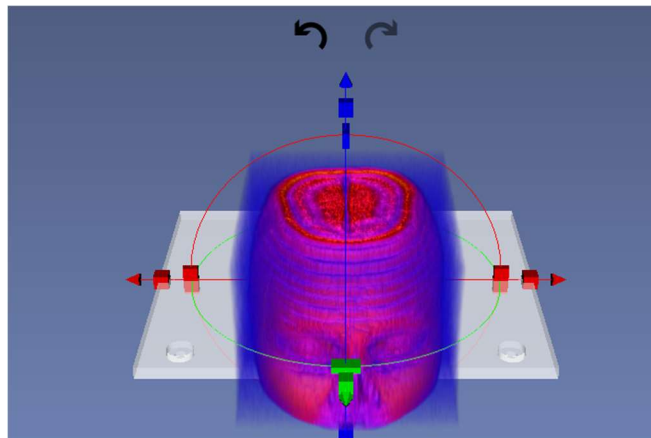
Importing a NifTI file into the modeling environment:

1. Click on the Import NifTI icon in the **Import** section.
2. Navigate to the folder containing the NifTI files
3. Highlight the desired file and click the 'Open' button to import the model.
4. The object will appear in the modeling environment. As in the case of objects created in TSIM, you will have the ability to modify the imported object via the **Objects** menu on the right-hand side.



Importing DICOM images into the modeling environment:

1. Click on the DICOM icon in the **Import** section.
2. Navigate to the folder containing the DICOM files.
3. Click 'Select Folder' to import the model.



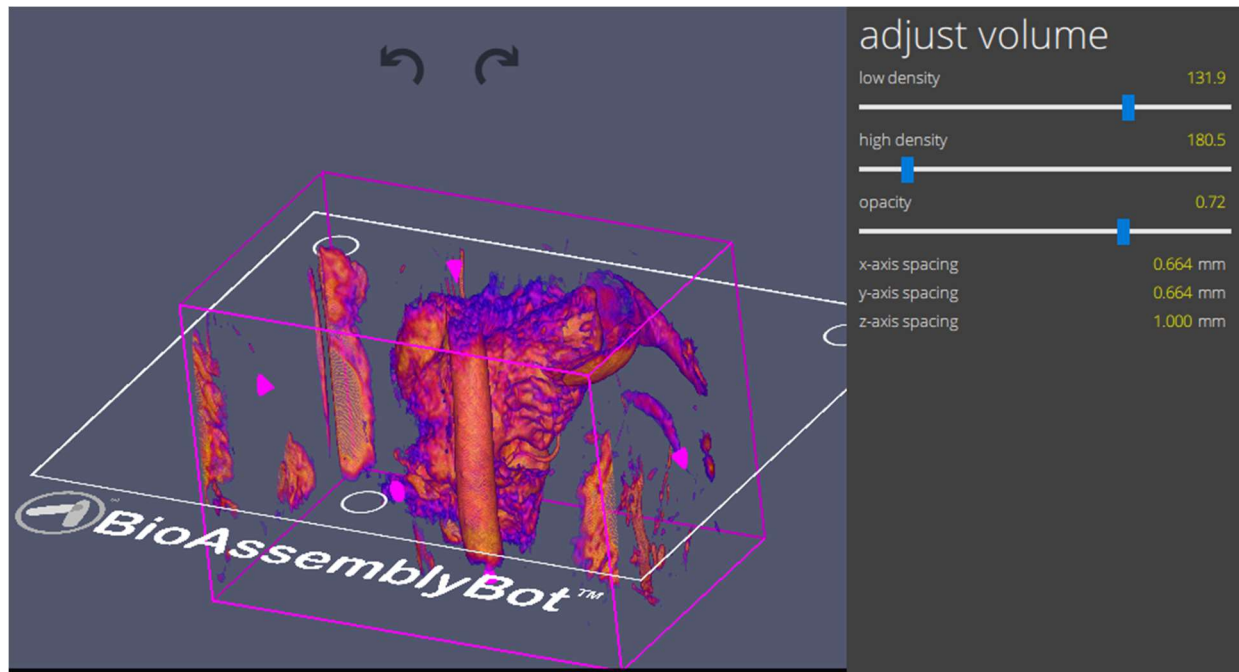
Volume



The Volume tool enables you to further analyze your volumetric model (NIfTI or DICOM) by adjusting density or opacity values. The spacing values for each axis may be modified as well.

1. Begin by importing the volumetric file (See [Importing a model file](#)).
2. Click on the **Volume** icon.
3. Click on the imported model to highlight it. The **Adjust Volume** menu will now be displayed on the right hand side. By adjusting the individual sliders, you can change the respective value, which in turn updates the model.

Note: you can still [change your viewing angle](#) while you make adjustments to the volume.



Sketch

TSIM provides you with additional tool to assist you in situations requiring you to draw your own objects. These can be accessed via the **Sketch** panel and the tools available are:



Create a sketch



Modify a sketch



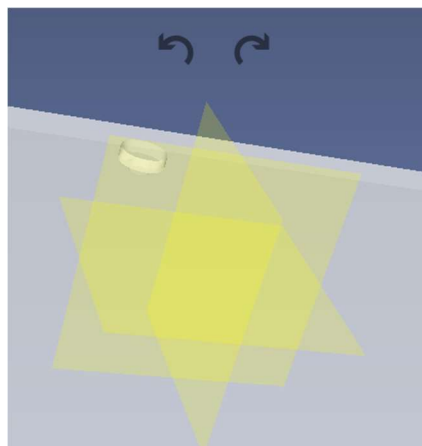
Manage Sketch



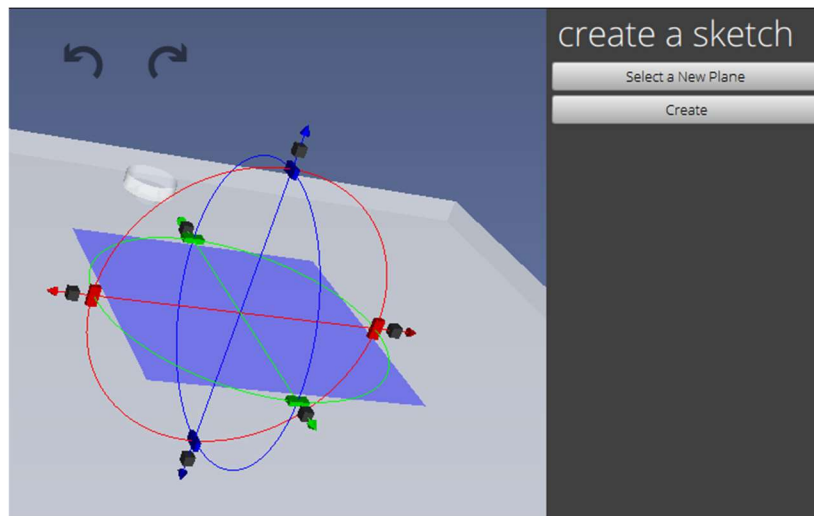
Generate Vascular Tree from parameters

Creating a custom object using the 'Create a sketch' tool

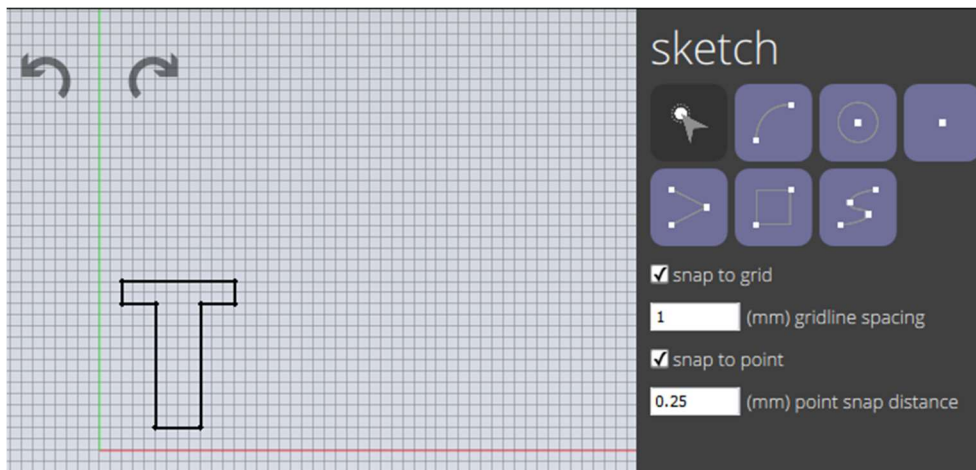
1. Click on the **Create a sketch** icon.
2. The three individual planes will appear in yellow. To choose the plane onto which your sketch will be drawn, simply click on the desired plane.



3. Your chosen plane will now appear highlighted in blue together with the interaction widgets. You may use the widgets to either move or rotate the selected plane.
 - Click on the **Create** button to begin working on your sketch.
 - If you would like to select a different plane, choose the **Select a New Plane** button to return to Step 2.



4. The selected plane will now be displayed as a grid and the **Sketch** menu will appear. Here you can draw custom objects by using curves, circles, points, rectangles, etc.




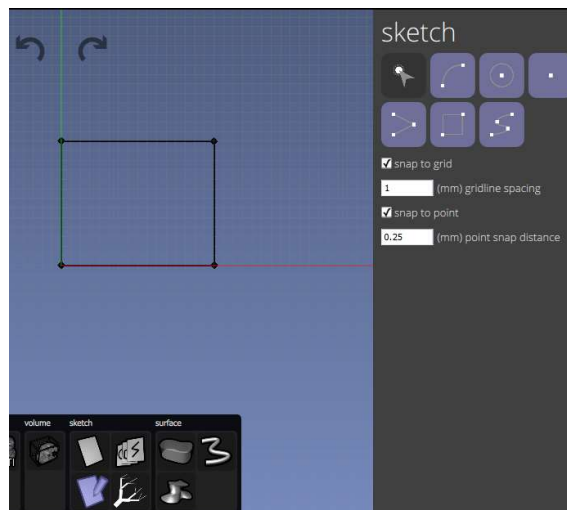
5. Once you have completed drawing your object, right-click to stop drawing and click on the **Select** tool to return back to the **Solid Modeling** screen.

Modify Sketch

The **Modify Sketch** tool allows you to make changes to an existing sketch.

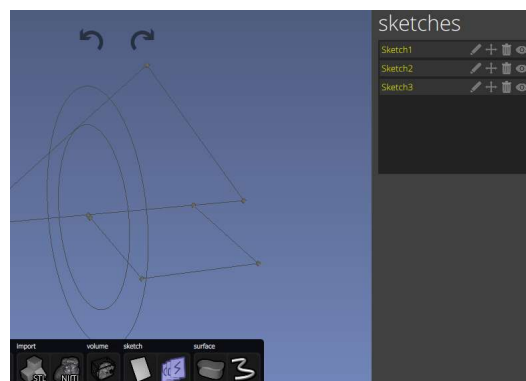
To use the tool:

1. If you have an existing sketch, click on the Modify Sketch icon 
2. The **Sketch** menu will now be viewable and you can make the necessary modifications to the sketch.



Manage Sketches

More complicated objects will consist of a collection of sketches made on different planes. TSIM's **Manage Sketches** tool allows you to modify, move, delete or hide individual sketches in a collection. Additionally, you may rename sketches from the default **Sketch** to a more relevant name.



In the above figure, there are three sketches (concentric circles, triangle, square) and you can interact with each sketch individually via the sketches menu on the right.

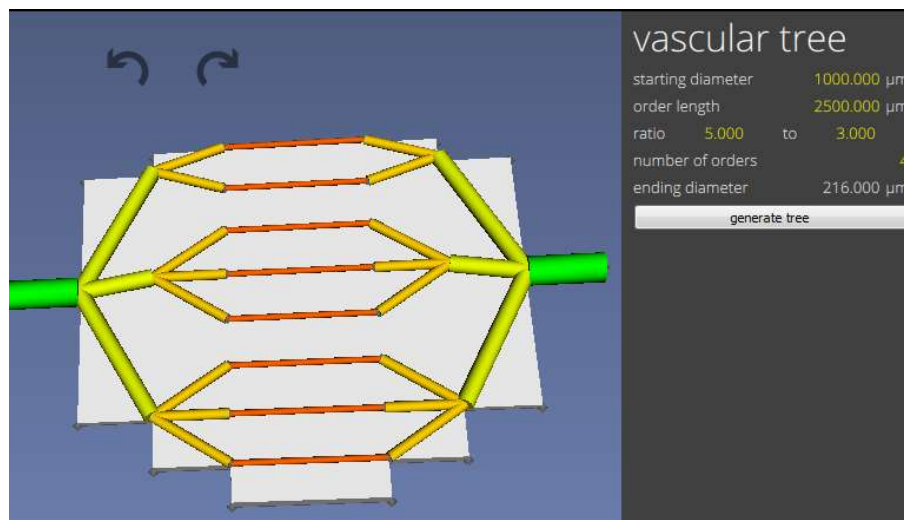
Generate Vascular Trees from parameters



TSIM allows you to create a 3D model of a vascular tree by entering in a set of input parameters via the Generate Vascular Tree icon in the **Sketch** menu. These include:

Starting diameter (μm)	Diameter of the largest vessel at the end.
Order length (μm)	Width of the order.
Ratio	Determines the decrease in size from one order to the next.
Number of order	The number of steps down in the pattern
Ending diameter (μm)	Diameter of the largest vessel at the end.

Once the model is generated, you can assign a specific material to each order of the vascular tree. The BioAssemblyBot is a unique printer because it utilizes eight different syringe barrels containing different materials (more, if your BioAssemblyBot is equipped with the Dual Dispense tool) that can be changed automatically.




Surface

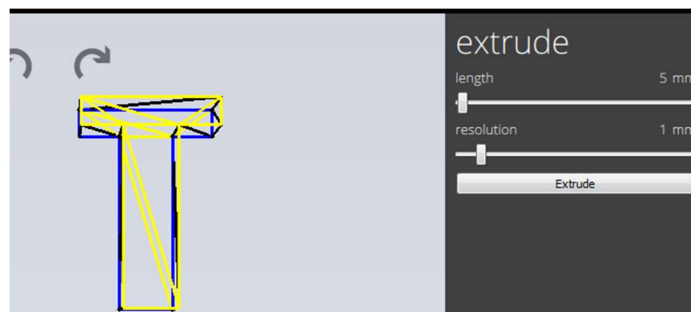
The **Surface** panel provides you with a tool to take a sketch and convert it into a 3D model. Let us consider the sketch made in the previous section.



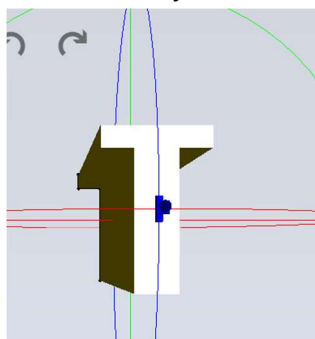
Create Surface from a sketch

To extrude the sketch into an object:

1. Begin by clicking on the **Create a surface from sketch** icon. 
2. You will be presented with an overhead view of your sketch.
3. Next, hold your CTRL key and click on each of the individual sides of the sketch. Selected sides will be highlighted in **blue**.
4. A wire frame of the object will be displayed when all sides are connected. The **Extrude** menu on the right side will now be active and allow you to adjust both the length and resolution of the extrusion.



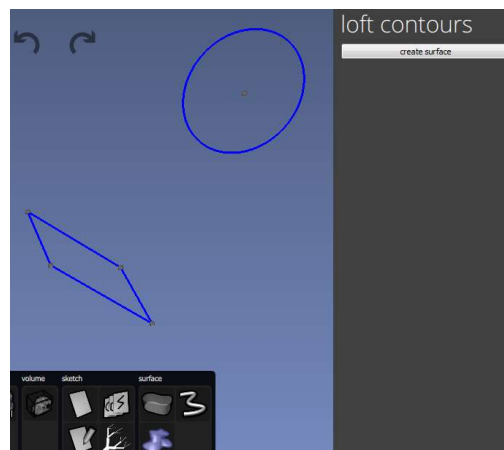
5. Click on the **Extrude** button to create the final object.



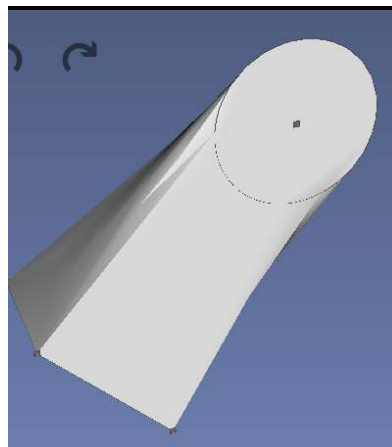
Create Surface from sketched profiles

In the case of the **Create a Surface from sketch** tool, you created a object from a single sketch profile. TSIM also allows you to select multiple sketches and created a new object by lofting the contours.

In the figure below, two individual sketches exist on different planes. Begin by clicking on the **Create Surface from sketched profiles** icon from the **Surface** menu. Next, you need to click on the lines of the objects to select them. Once everything is selected, click on the **Create surface** button located under **Loft Contours** on the right side.



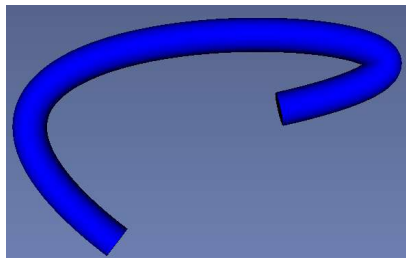
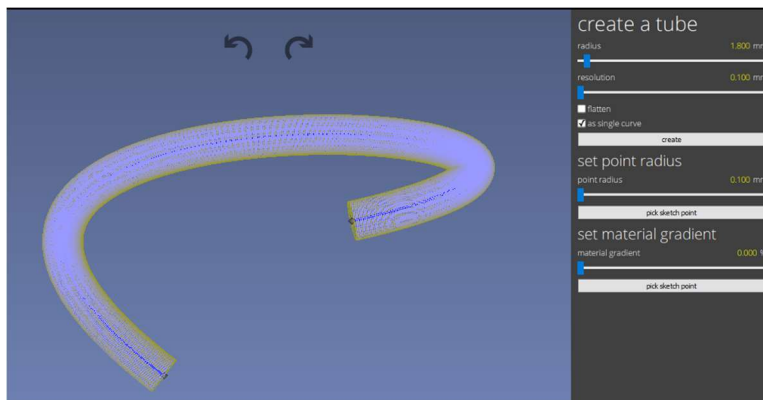
Once completed the individual sketches will be used to form a new 3D object, as seen in the image below.



Create a Tube along a sketched curve



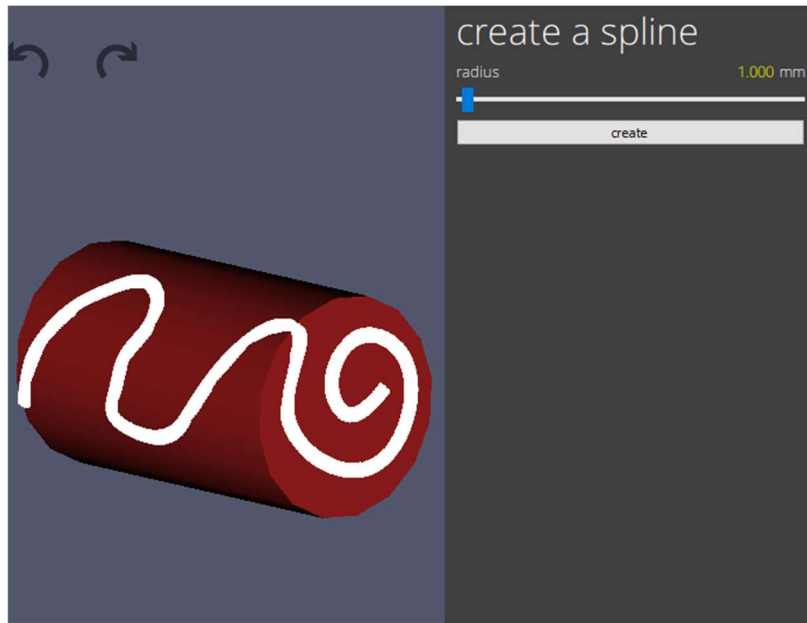
The **Create a Tube** tool allows you to take an existing curve of circle and create a 3D tube. You have additional control over the radius and resolution of the generated tube. You can also set the radius or material gradient percentage at a particular sketch point.



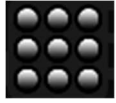
Sketch a 3D Spline along a surface



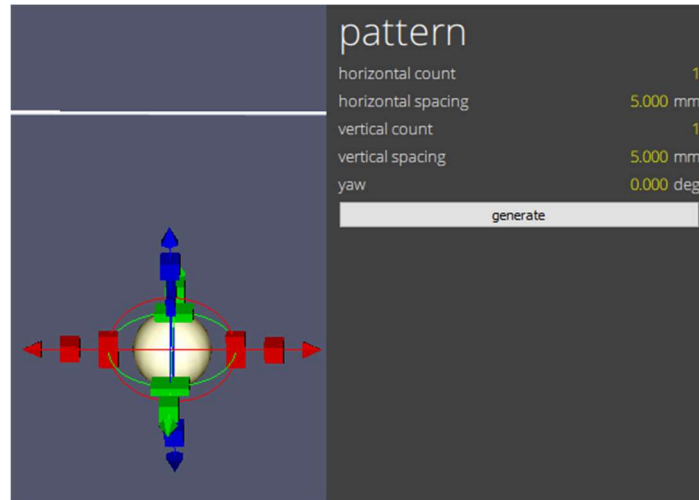
The **Sketch A 3D Spline** tool allows you to take create a spline on an existing 3D mesh. You have additional control over the radius and resolution of the generated tube. You can also set the radius at a particular sketch point.



Array Pattern of objects



The **Array** tool allows you to select an object and create a pattern of multiple of that same object. The options you have are horizontal count, horizontal spacing, vertical count, vertical spacing, & yaw. **Yaw** will generate the pattern with a rotation around the Z axis.



For example, the following settings create the image below:

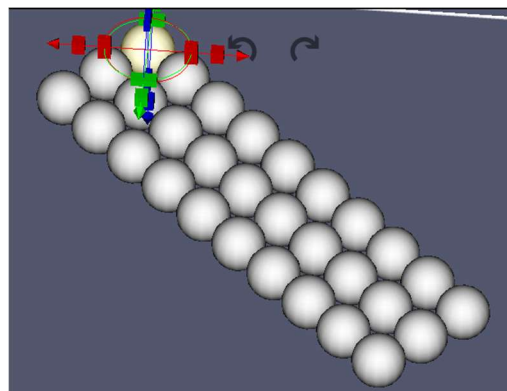
horizontal count = 3

horizontal spacing = 20.000 mm

vertical count = 10

vertical spacing = 20.000 mm

yaw = 45.000 degrees



Generate structural supports



Generates tubular supports under voids.

structural supports

selected solid

nothing selected yet

select an entity

characteristics

base diameter	3 mm
cap diameter	1 mm
cap height	1 mm
base center spacing	6 mm

generate supports

Generate surface tubes



Create surface tubes allows you to select an object to generate a tube pattern on its surface. Select the entity using the select and entity button and fill out the parameters.

- Tube Diameter – size of the tubes generated
- Tube resolution – number of faces used to construct the tube wall
- Tub spacing – spacing between tubes generated
- Minimum length – minimum tube length to generate. (If the surface is too small no tube will be generated).
- Max. point spacing – Maximum space between tube vert points.
- Maximum angle – the maximum angle on the surface that the tubes will be generated. If you are using a sphere for example a 90deg value will cover ½ of the sphere.
- Number of layers – Number of tube layers to generate

- Combine tubes – If checked, one mesh will be made for all tubes. If uncheck each tube will be an individual object.

surface tubes

selected solid

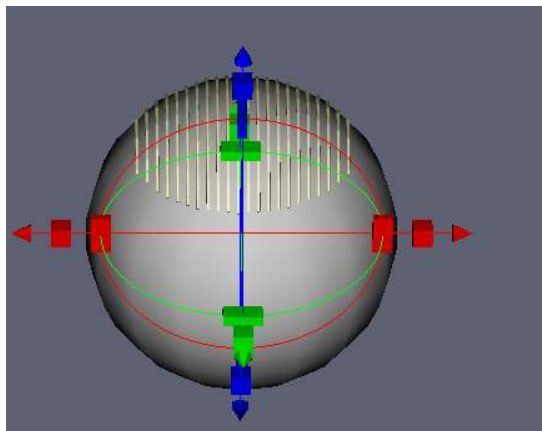
nothing selected yet

select an entity

characteristics

tube diameter	0.5 mm
tube resolution	0.25 mm
tube spacing	1 mm
minimum length	3 mm
max. point spacing	5 mm
maximum angle	45 deg
number of layers	1 layers
<input type="checkbox"/> combine tubes	

generate tubes



Materials

Materials are bioinks that are used to print out the solid models. To modify materials, click on “Materials” at the top of the TSIM window. This will bring you to the **Materials** screen. Any changes made to materials take effect instantly.

Name	Description	Color	Pressure (psi)	Pressure 2 (psi)	Start Delay (ms)	Acceleration (mm/sec ²)	Speed (mm/sec)	Line Width (mm)	Line Height (mm)	Temp. Control	Temp (°C)	Light Position	Lens Diameter (mm)	Light Intensity
10% gelatin ...	GelMA 10% - 0.5PI	Black	45	0	500	500	10	0.3	0.3	None	0	Cure while printing	12	0
21B	Pluronic80-Gelatin20	Yellow	40	0	250	500	10	0.3	0.3	None	5	Cure while printing	12	0
25G	10% gelatin 30 G	Blue	4	0	500	10	4	0.5	0.2	Heated	34	Cure while printing	12	0
25H	25B Blue	Blue	30	0	200	500	10	0.3	0.3	None	0	Cure while printing	12	0
25I	pl wall Green	Green	40	0	500	500	5	0.5	0.6	None	0	Cure while printing	12	0
25J	25GA Red	Red	80	0	100	100	5	0.45	0.45	None	0	Cure while printing	12	0
25K	25GA Yellow	Yellow	36	0	500	5000	5	0.6	0.5	None	0	Cure while printing	12	0
32G	32 GA Pluronic	Grey	70	0	600	500	1	0.2	0.2	None	0	Cure while printing	12	0
BC collagen	BC collagen	Pink	0.8	0	200	1	1	0.2	0.15	Cooled	5	Cure while printing	12	0
16 Wall Plate	16 Wall Plate	Green	40	0	300	250	4	0.47	0.2	None	0	Cure while printing	12	0
86 Wall Plate	86 Wall Plate Test	Green	30	0	500	500	2	0.7	0.5	None	0	Cure while printing	12	0
BB002 21G L	BB002 21G Long	Green	25	0	250	100	5	0.75	0.5	None	0	Cure while printing	12	0
BB002 25G L	BB002 25G 1/4" Red	Red	34	0	150	0	2	0.75	0.42	None	0	Cure while printing	12	0

To add a new material, click the *add material* button.

To remove an existing material, select it, and click the *remove material* button.

The parameters in the list are as follows:

Name – The name of your material.

Description – The description of your material. This is shown the material loading screen.

Color – Clicking on this will bring up a RGB color scale. Choose a color in this scale. This color is only used as a visual marker in TSIM®, and has no effect on the print.

Pressure (psi) – The material in the barrel will be extruded at this pressure during the print.

Secondary pressure (psi) – Only on BioAssemblyBots® equipped with an Ambient Dual Dispense tool. The material in the secondary barrel will be extruded at this pressure during the print.

Start Delay (ms) – When the robot prints, movement will first be delayed for this number of milliseconds, but the pressure will still be applied, so material will extrude.

Acceleration (mm/sec²) – The robot will move with this acceleration while printing this material.

Speed (mm/sec) – The robot will move with this speed while printing this material.

Line Width (mm) – When generating the paths to build the object desired, the robot will assume that the material will extrude with a line width of this value.

Line Height (mm) – When generating the paths to build the object desired, the robot will slice the object into layers. The layers will have a line height of this value.

Layer Change Action – BioAssemblyBots® only. When pause between layers is selected, the printer will stop between each layer and wait for the user to open and close a door. This can be used if you need to do manual crosslinking and you do not want to manually pause the machine.

Print behavior Overprint – When this setting is selected, the entire print volume will be filled with material even if it is not divisible by the line width. The last path will over print to ensure everything is filled. This can potentially cause build up over large prints if the remainder is always in the same location.

Print behavior Underprint – When this setting is selected, the remainder of the print volume will be left empty. If a volume is not divisible by the line with, this extra area will not be printed inside the volume.

Temp. Control – Only on BioAssemblyBots® equipped with a Heating or Cooling tool. This can be set to Heated or Cooled. If left as None, the ambient temperature will be used and the value in Temp (c) will be ignored. If set to Heated or Cooled, the material will be heated or cooled to the desired temperature set in Temp (c). The BioAssemblyBot® must have a Heating or Cooling tool for each material which requires heating or cooling.

Temp (degrees C) – Only on BioAssemblyBots® equipped with a Heating or Cooling tool. This is the temperature the Heating or Cooled tool will hit before a print, then maintain during the print.

Light Position – Only on BioAssemblyBots® equipped with an Ambient Light Head tool. This is the desired position of the light head during the print. Currently, this is “Cure while printing” but will be expanded in the future.

Lens Diameter (mm) – Only on BioAssemblyBots® equipped with an Ambient Light Head tool. This is the diameter of the lens screwed on the end of the light head. Currently, this is “12 mm” but will be expanded in the future.

Light Irradiance (mw/cm²) - Only on BioAssemblyBots® equipped with an Ambient Light Head tool. This is the level of irradiation applied to the material during the print. This can vary depending on calibration, but is approximately 40 – 400 mw/cm² with a 12 mm lens. Please see the *BioAssemblyBot® User Manual, Calibration > Light Heads* section for more details on range.

Each of these parameters can be modified as below:

name	HB Bone	pressure (psi)	35 psi	line width	0.4 mm	temp. control	None
description	Material 4	secondary pressure (psi)	0 psi	line height	0.4 mm	temperature	0 °C
color		start delay	1000 ms	layer change action	None	light position	Cure while printing
		acceleration	400 mm/sec ²	print behavior	Overprint	lens diameter	6 mm
		speed	5 mm/sec			light wavelength	365 nm
						light irradiance	0 mW/cm ²

BioAssembly

This tab is applicable if a BioAssemblyBot® is currently connected to the TSIM® PC.

It displays a list of print jobs that are currently stored on the BioAssemblyBot®, and current camera feed from the BioAssemblyBot®. In this screen, the user can:

- View all potential print jobs available on the BioAssemblyBot®
- View all events that have occurred on the BioAssemblyBot®
- Send the solids shown in the Solid Modeling tab to the BioAssemblyBot® as a print job
- Delete an existing print job on the BioAssemblyBot®

Send Print Job

Clicking this button will send all solids to the BioAssemblyBot® and create a new print job out of them, assuming they have a material assigned and are currently visible in the view. The print job will be displayed in the *Print Jobs* list.

Delete Print Job

Selecting a print job in the Print Jobs list and clicking this button will delete the print job from the BioAssemblyBot®. The print job will be removed from the *Print Jobs* list.

Print Jobs tab

This tab shows the complete list of print jobs available on the BioAssemblyBot, and also list their name, the number of solids in the print, number of materials in the print, and who and when the print job was submitted by.

Events tab

This tab shows the major Events that have occurred on the BioAssemblyBot®, such as completion of print jobs, door opening and closing, safety information, system startup, and system shutdown.

Basic

This tab is visible and applicable if a BioBot® Basic is currently connected to the TSIM PC. In this screen, the user can:

- Recalibrate the stage height
- Load new materials into the turret
- Print the solids shown in the *Solid Modeling* tab
- Cancel a print in progress

Stage Height

The BioBot® Basic stage or surface it is placed on may not be perfectly level. To ensure that the prints created are placed correctly on the stage, the user must calibrate the stage height. This step is recommended to be performed the first time a BioBot® Basic is used, if the stage is swapped out, or if the stage is hit forcefully. To calibrate the stage height, follow the instructions displayed on the left side of the **Basic** tab.

Load Materials

The BioBot® Basic features a turret which can hold five materials at one time. To remove the turret, click the Load Materials button. This will make the BioBot® Basic disengage the turret. Now the two thumbscrews on either side of the turret can be turned counterclockwise, and the barrel can be removed from the turret.

Print

The BioBot® Basic can print out the currently displayed solid objects in the **Solid Modeling** tab, assuming they have a material assigned and are currently visible in the view. To print, click the *Print* button. This will start a progress bar which shows the status of the current print.

Cancel

This button is disabled until a print job is started via the *Print* button. If a print job needs to be canceled, the Cancel button can be clicked. The BioBot® Basic will stop the current print, and will return the BioBot® Basic to the home position.

Help

Clicking **Help** will bring up the default web browser on the TSIM® PC, which will allow the user to download the latest copy of this TSIM® User Manual.

About

Clicking **About** will show the current version and build date of TSIM®, and will allow the user to enter all feedback on TSIM® desired.

Submit

The user can enter a valid email address and all feedback and comments into the Email Address and Comments sections. Clicking *Submit* will then send this information to the Advanced Solutions Life Sciences team.