GUIDE TO 3D PRINTING

NEWSCHOOL OF ARCHITECTURE + DESIGN
MATERIALS LAB

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THEORY

The technology of 3D printing is based on the concept of additive manufacturing, which is the creation of a product through the addition of material. This can be contrasted to the more traditional subtractive manufacturing method which involves the removal of material from a source stock, as in milling operations.

Additive manufacturing has a number of advantages over traditional manufacturing methods. With additive manufacturing less material is required as it is placed only where needed. Also, this allows for the creation of unique parts which would be challenging or unavailable through traditional manufacturing methods. Lastly, without the need for custom dies, molds or fixtures, additive manufacturing can create new parts at low cost in a rapid time frame.

PROCESS

To understand how a 3D print is created it is beneficial to think of the printing process in terms of a known physical object. If you picture a 3D model as a loaf of bread imagine slicing the bread into pieces. Then rotate the loaf vertically and begin stacking the pieces one at a time until the loaf is assembled into its original form.

This same process is how the printer slices the model into layers then builds each subsequent layer during the printing process. Each new layer builds upon the prior until the model is completed; but rather than one thick slice at a time layers can be as thin as 0.01 mm. The final product is a cohesive solid built 1 layer at a time.

BENEFITS

There are a number of different forms of 3D printing available but for the purpose of this discussion we will reference Selective Laser Sintering or SLS printing which is what is available in the NSAD Materials Lab. This form of printing shares many benefits with other types of 3D printing as well as some unique to SLS.

Generally speaking, all 3D printers create a physical model directly from a digital model. There are different materials but our final material is Nylon 12 which is a food-safe, white, nylon plastic which can be painted, cut or sanded after printing. The other distinction of SLS printing is the lack of support material. Most 3D printing requires support as parts are built 'in space', but the SLS process is self-supporting which allows much more freedom with part creation.

MODEL

To build a quality 3D print you must first start with a quality model. The required model type is a mesh model saved in the STL format with units set to millimeters. The model should be scaled to the correct dimensions and include only one piece in each STL file. The model must be a solid which means no single surfaces or naked edges. A solid converted to a mesh becomes a single 'water-tight' shell with no naked edges. The only exception to single shell is models with multiple combined elements, such as a hinge, which may have multiple single shells.

If there are walls in the piece aim to make them no thinner than 1 mm. If you want movement in a piece, provide a 0.5 - 1 mm tolerance between moving parts. Lastly, the overall size of a model has the greatest influence on cost so consider splitting large files into separate pieces or remove items which contribute to excessive volume.

COSTS

Cost is often the first question asked but it varies greatly with each model. For a rough estimate of pricing for students, calculate the overall outside volume of the part and estimate $1.25 per a cubic inch of volume. With this in mind, recognize that doubling the scale of a part will often increase the cost over 400%, conversely scaling a part in half can reduce costs by 75%.

Another key factor is part orientation, tall parts that exceed the length and width of the deck and must be stood vertically can be very costly; if the printer has to go up 100 mm for a single part the individual will have to pay the cost of the entire deck going up 100 mm. Finally, the efficiency of printing with SLS comes from nesting a large number of parts within a single run. For this reason we combine many user parts in a single run to reduce individual costs for everyone.

CONSTRAINTS

Size: The buildable area is 180 mm x 230 mm by 310 mm
Time: Plan for at least 24 - 48 hours
Wall Thickness: 1 mm minimum
Colors: White (but it does accept acrylic paint readily)
Cost: Approximately $1.25 a cubic inch for students
Units: Use millimeter units to avoid scaling issues
File Type: Only STL mesh format files
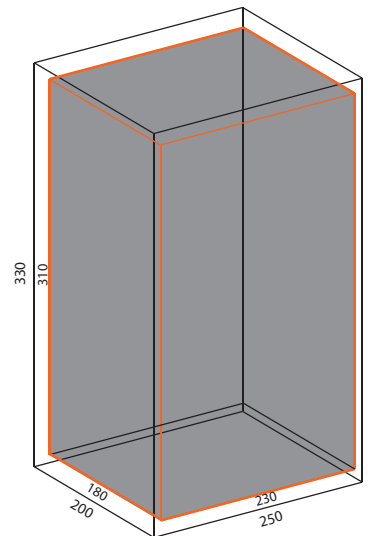
FILE PREP

File preparation is the most important component for producing a quality 3D part. This means the part must be a single "water-tight" mesh meaning a solid part with no naked edges. Aim to make and keep your part a solid throughout the design process to end up with a quality solid in the end.

Some simple steps in Rhino that can help are:
- <u>Boolean</u> parts together, not join or group
- <u>Unify Mesh Normals</u> to keep faces aligned
- <u>Align Mesh Vertices</u> to help close gaps in meshes
- <u>Reduce Mesh</u> to simply mesh face counts if your file is larger than 5 mb
- <u>Mesh Repair</u> to verify your file is OK BEFORE bringing it to the lab.
- <u>Show Edges</u> to locate and close any naked edges

LINKS

- Rhino Mesh Settings:
- http://wiki.mcneel.com/rhino/meshfaq
- Rhino Mesh File Prep Guide:
- http://isites.harvard.edu/fs/docs/icb.topic907832.files/preparing-3D-print-files.pdf
- STL File Repair in Rhino:
- http://www.design.upenn.edu/files/STL_Repair.pdf
- Scan, Cleanup and Remodel in Rhino:
- http://design.umn.edu/current_students/leo/hall/documents/ScanCleanupRemodel.pdf
- Exporting to the STL Format for 3D Printing:
- http://www.lynda.com/Rhino-tutorials/Exporting-STL-format-3D-printing/133324/153973-4.html
- Revit to STL Exporter:
- http://apps.exchange.autodesk.com/RVT/en/Detail/Index?id=appstore.exchange.autodesk.com%3Astlexporterforrevit%3Aen
- Model Preparation in Rhino:
- http://www.willamette.edu/~pdwyer/modelprep.pdf
- How to Fix Almost Any Surface:
- http://fab.cba.mit.edu/classes/MIT/863.09/people/john/3d-guru.pdf
- Advanced Mesh Repair in Rhino:
- http://vimeo.com/80934690
- NetFabb Mesh Repair Tool:
- http://www.netfabb.com/
- Autodesk Meshmixer
- http://www.123dapp.com/meshmixer