# 3D Printing

Introduction to 3d printing concepts

Rebecca Massey
Technology Support

1

## What is 3d Printing?

3d Printing encompasses many different types of technologies and materials to produce prototypes, parts and products.

2

## Types of 3d printing

Additive vs. Subtractive Manufacturing

- Additive manufacturing (or printing) is the process of repeatedly adding material, layer by layer to build a 3D print from a raw source material.
  - Examples: Fused Deposition Modeling, Powder Bed Fusion, Light Polymerization
- Subtractive manufacturing (or printing) is the process of starting with a solid raw source material and removing portions of the material layer by layer to produce a 3D print.
  - Examples: CNC, Routing, Laser Etching

3

## Additive Printing

Powder Bed and Inkjet Head

- Uses thermoplastic powder or gel
- Soluble support structures
- Final product is high heat and chemical resistant
- Can produce multicolored objects
- Example: Stratasys Polyjet

Images: www.stratasys.com

4

## Additive Printing

Stereolithography (SLA)- Resin

- UV lasers or projectors
- Cures UV reactive resins
- Faster production time
- Single color or multi color
- Supports may be used
- Example: Formslabs Form 2

Images: www.formlabs.com

5

## Additive Printing

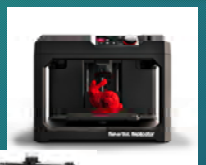

Image: www.robosavvy.com

Image: www.engadget.com

Fused Deposition Modeling (Extrusion)

- Uses thermoplastics, edible materials, rubbers, eutectic metal, composite metal-PLA
- Soluble or solid support structures
- Cheapest 3d print production option
- Example: MakerBot Replicator, PancakeBot, Ultimaker

6

## Use Cases for 3D Printing

7

## Medical Research and Prosthetics


Image: www.3dprintingindustry.com


Image: www.cyborgbeast.org


Image: Jonathan T. Butcher, Cornell University

- Bioprinting blood vessels, heart valves, synthetic skin, even organs – using bio-ink
- Custom prosthetic printing
  - Alternative access in remote or low income regions worldwide
- Bone replacement/grafting
  - Custom printed skull pieces
  - Bone scaffolds to encourage healing and regrowth of broken bones

8

## Space Exploration

- International Space Station has a 3D printer
  - Potential for part replacement and emergency maintenance
  - Plans have been transmitted to the station from Earth and produced in space
  - Flexibility of designing and producing parts as needed encourages long distance exploration


Image: www.nasa.gov

9

## Disaster Recover & Construction

- Large scale 3D printers have been used to craft concrete components
- Components can be either printed in place, or at a warehouse, then trucked to a building site
- Huge potential to build long term or temporary housing after a disaster

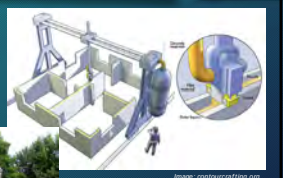

Image: contourcrafting.org

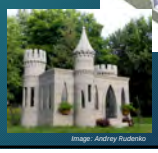

Image: Andrey Rudenko

10

## Rapid Prototyping and Hobby/Home

- 3D printing allows rapid transition from design to implementation and prototyping a proof of concept
- Home and hobby enthusiasts see the potential to print replacement parts and custom art and design objects

Image: www.cel-robox.com

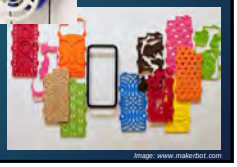

Image: www.makerbot.com

11

## ATLC – IT3D Printing

12

## IT3D Equipment

- MakerBot Replicator 2
- MakerBot Replicator+
- MakerBot Z18
  - Fused Deposition Modeling
  - Objects build layer by layer from the base up
  - Uses thermoplastic PLA filament
  - Single color printing
  - 11 color options




Images: www.makerbot.com

13

## 3D Design and Production Software

- Many programs facilitate the design of 3D files:
  - Autodesk Inventor (available in ATLC computers labs)
  - Autodesk Fusion 360 (free to students via Autodesk)
  - Google Sketchup (freeware)
  - Blender (freeware)
  - Tinkercad (free web based application)
- Programs that repair or check completed 3D files:
  - Autodesk Netfabb (free to students via Autodesk)
  - MeshLab (open source)
- Programs for printing 3D files (slicing programs):
  - MakerBot Desktop (free)
  - Skeinforge (freeware)

14

## Design Elements

- "Water tight"
  - Mesh
  - Faces
  - Holes
- Overhang/Unsupported Structure
  - Linear layer printing requires that each layer be built upon a previous layer or the original base structure.
- Support Structure/Rafts
  - Supports are used when an object layer would otherwise be built "on air", which is impossible for FDM printers.
  - Rafts are used to ensure that an object stays adhered to the build plate and does not curl during printing.
- Scaling
  - Some design software products produce elements in measurements of inches. MakerBot printers and software work in millimeters. Scaling and conversion are sometimes necessary to ensure accurate final product.

15

## Design Elements – cont.

- Infill
  - Standard is 10% (objects are mostly hollow)
  - Increases will raise print time and final weight/cost of the object
- Resolution
  - Standard is 0.2mm layer height
  - Decrease in layer height will raise weight/cost and increase overall print time
- Number of shells
  - Standard is 2 shell layers
  - Increases may affect final print quality and increase print weight/cost, but reduce print time

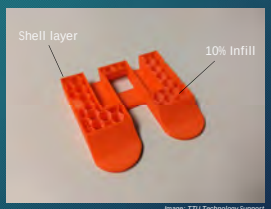

Image: TTU Technology Support

16

## Design with Production in Mind

Good ideas:

- Minimize the use of overhangs
  - Most printers can print up to a 65º to 68º overhang without issue
- Make sure your object is solid
- Keep your smallest elements over 1mm in width/diameter
- Use a material that suits your end purpose
- Set your scale to millimeters
- Separate objects into different files

Avoid:

- Overly complex structures
- Highly detailed surface features
- Unfinished models
  - Holes, gaps, inverted faces
- Multiple objects on different planes within the same file
- Floating objects or elements

17

## Finding a 3D Print File

- There are numerous community driven file archives for 3D print files. Most community archives are free. A few examples:
  - Thingiverse (run by MakerBot Industries) – www.thingiverse.com
  - YouMagine (run by Ultimaker) – www.youmagine.com
- Some archives are pay-to-print services. Depending on the service, you can either purchase the .STL file alone or pay an additional cost to have a 3D file produced and shipped to you. Examples include:
  - Shapeways – www.shapeways.com
  - i.materialise – www.i.materialise.com

18

## ATLC 3D Print Submission Process

- www.3dprint.ttu.edu
- "Submit a 3D Printing Project Request"
- Files must be 5mb or smaller
  - Larger files can be transferred by email or LFT service
- Each project can consist of up to 10 job files
- Accepted formats: .thing, .stl, .obj
- Prices: $2.00 per project + $0.10 per gram final weight

19

## ATLC 3D Submission Process (cont.)

1. Project Request is initiated
2. IT3D team reviews files and submits cost estimate to customer for approval
3. Customer approves
4. Print job enters the production queue
5. Customer is notified when all jobs for a project are complete
6. Customer picks up completed project at ATLC Reception Desk

In the event of misprints, or concerns, the IT3D team will contact customers directly to clarify any concerns or problems.

20

## Additional Campus Resources

- ATLC 3D printing service
  - 3dprint.ttu.edu
  - Open to students, faculty, and staff
  - Projects can be personal or academic
  - Fees: $2 project fee (up to 10 jobs), $0.10 per gram of material
- TTU Libraries Makerspace
  - http://library.ttu.edu/make/resources.php
  - Additional 3D rendering and design resources available
  - Open to students, faculty and staff
  - Projects can be personal or academic
  - Fees: $1 project fee, $0.06 per gram of material
  - Fees can be waived for academic or approved projects
- TTU College of Architecture Fabrication Lab:
  - www.arch.ttu.edu/wiki/3D_Printing_Instructions
  - Projects must be academic
  - Fees vary by printer model

21