

Rather Useful Seminars

Creating 3D Objects in Software

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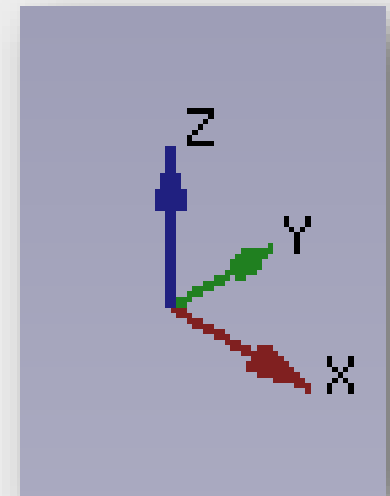
Department of Computer Science

Agenda

- How to think in 3D
- Messing with 3D in software
 - Playing with surfaces using C#
 - Using Python in FreeCad
 - OpenScad
- 3D printing

Thinking in 3D

- This was the hardest part for me
- Things got easier when I started thinking
 - X = width
 - Y = depth
 - Z = height



Making 3D Objects from triangles

- Everything in your 3D world is a triangle
- Everything
- A triangle is made from three *vertices*
 - A vertex (singular of vertices) is a point in 3D space that has an x, y and z coordinate

```
public struct Vertex
{
    public double X;
    public double Y;
    public double Z;
    public Vertex(double Xin,
                  double Yin, double Zin)
    {
        X = Xin;
        Y = Yin;
        Z = Zin;
    }
    public void STLWrite(BinaryWriter b)
    {
        b.Write((float)X);
        b.Write((float)Y);
        b.Write((float)Z);
    }
}
```

Making 3D Objects from triangles

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```
public struct Triangle
{
    public Vertex V1;
    public Vertex V2;
    public Vertex V3;
    public Triangle(Vertex V1in,
                   Vertex V2in,
                   Vertex V3in)
    {
        V1 = V1in;
        V2 = V2in;
        V3 = V3in;
    }

    public void STLWrite(BinaryWriter b)
    {
        V1.STLWrite(b);
        V2.STLWrite(b);
        V3.STLWrite(b);
    }
}
```

Making a mesh of things

```
List<Triangle> mesh = new List<Triangle>();
```

- One triangle is OK, but doesn't actually do much for us
- A collection of triangles lets us specify a surface or an object
- This can be called a mesh

Meshes

- For a mesh to be useful it has to be “closed”
 - There must be no gaps between the triangles
- We need to be careful about this when we create a mesh
- The good news is that we can just ship out the triangles to our CAD programs and they work just fine

Stereo lithography (STL) File

- The STL file format is one way object designs are passed around
- The file is essentially an enormous list of triangles
- There are two formats, binary and text
 - I use binary as it is smaller and faster to load

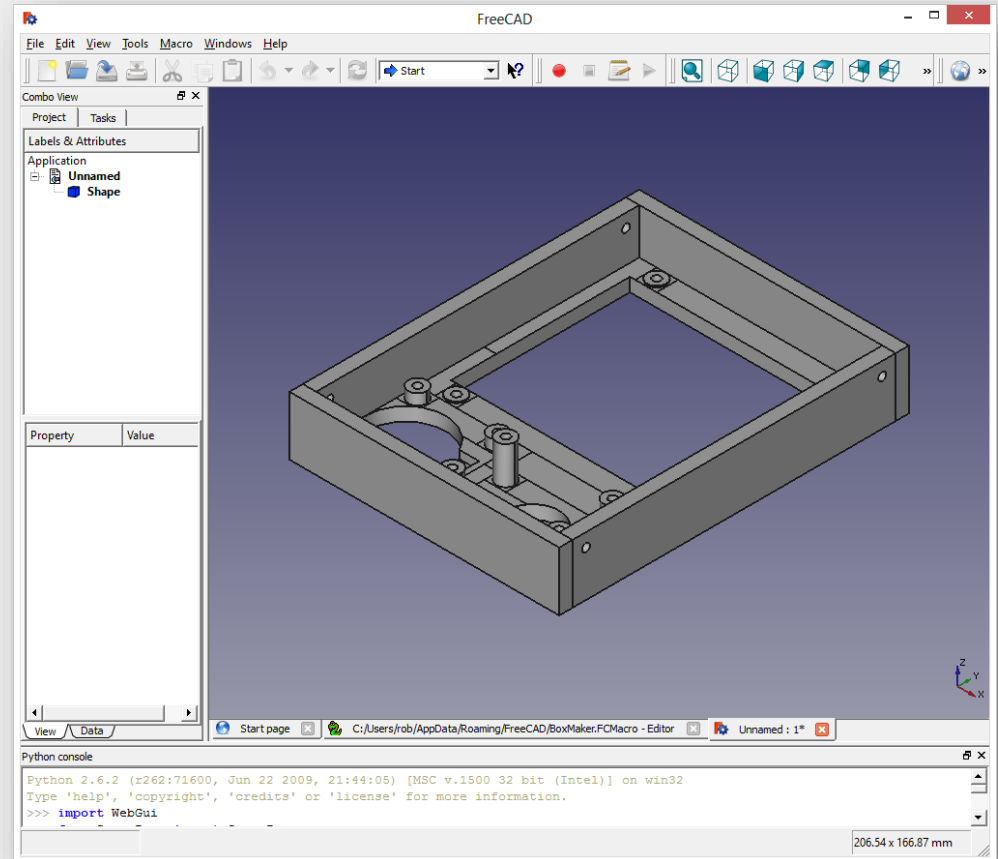
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DEMO 01

Making STL files from C# code

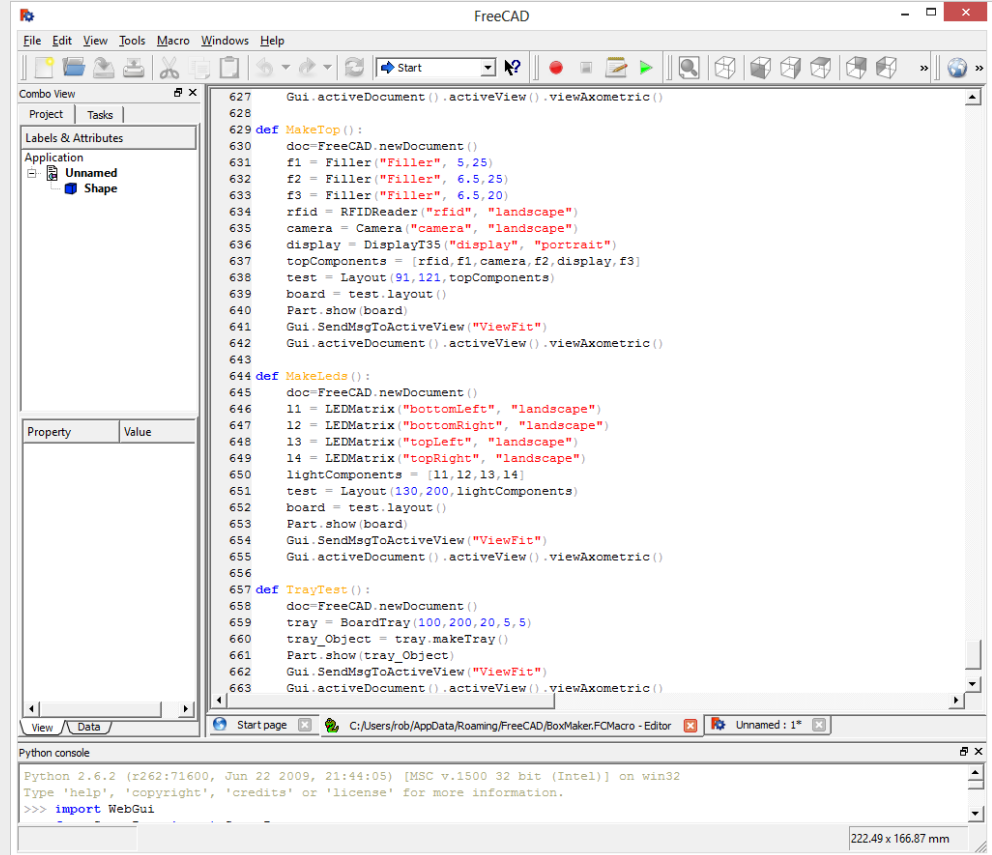
FreeCAD

- FreeCAD lets you design things in 3D
- This can be a bit painful
 - Visualising and manipulating things in 3D is hard



FreeCAD and Python

- One of the great things about FreeCAD is that it lets you generate objects using Python programs
- These run inside the tool and let you create objects programmatically

A screenshot of the FreeCAD software interface. The main window displays Python code for creating CAD objects. The code includes functions for creating a top view, a LED matrix, and a tray. The Python console at the bottom shows the execution of the code, including the import of the WebGui module.

```
627 Gui.activeDocument().activeView().viewAxometric()
628
629 def MakeTop():
630     doc=FreeCAD.newDocument()
631     f1 = Filler("Filler", 5,25)
632     f2 = Filler("Filler", 6.5,25)
633     f3 = Filler("Filler", 6.5,20)
634     rfid = RFIDReader("rfid", "landscape")
635     camera = Camera("camera", "landscape")
636     display = DisplayT35("display", "portrait")
637     topComponents = [rfid,f1,camera,f2,display,f3]
638     test = Layout(91,121,topComponents)
639     board = test.layout()
640     Part.show(board)
641     Gui.SendMsgToActiveView("ViewFit")
642     Gui.activeDocument().activeView().viewAxometric()
643
644 def MakeLeds():
645     doc=FreeCAD.newDocument()
646     l1 = LEDMatrix("bottomLeft", "landscape")
647     l2 = LEDMatrix("bottomRight", "landscape")
648     l3 = LEDMatrix("topLeft", "landscape")
649     l4 = LEDMatrix("topRight", "landscape")
650     lightComponents = [l1,l2,l3,l4]
651     test = Layout(130,200,lightComponents)
652     board = test.layout()
653     Part.show(board)
654     Gui.SendMsgToActiveView("ViewFit")
655     Gui.activeDocument().activeView().viewAxometric()
656
657 def TrayTest():
658     doc=FreeCAD.newDocument()
659     tray = BoardTray(100,200,20,5,5)
660     tray_Object = tray.makeTray()
661     Part.show(tray_Object)
662     Gui.SendMsgToActiveView("ViewFit")
663     Gui.activeDocument().activeView().viewAxometric()
```

Python console

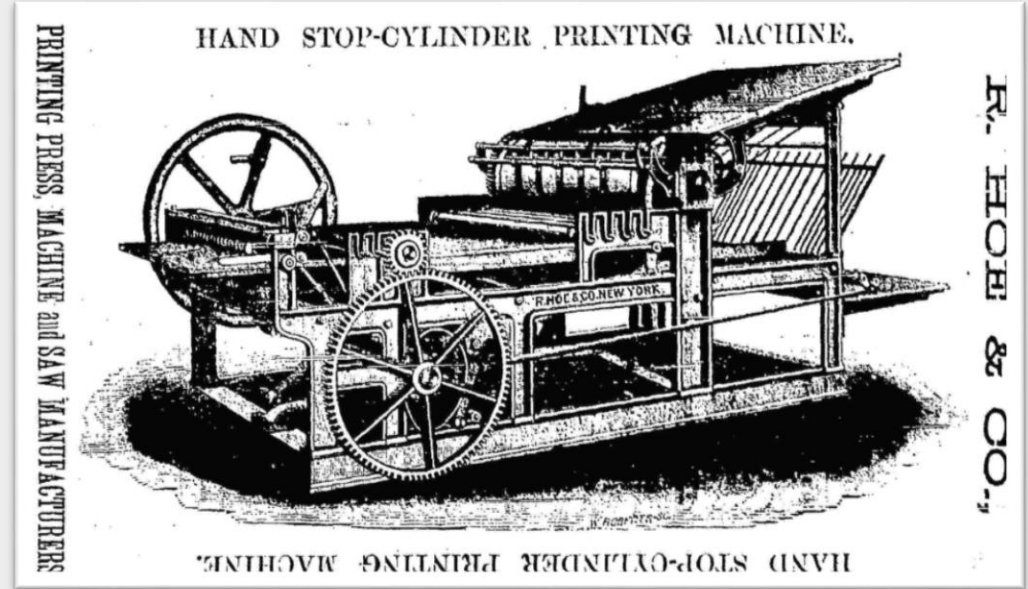
```
Python 2.6.2 (r262:71600, Jun 22 2009, 21:44:05) [MSC v.1500 32 bit (Intel)] on win32
Type 'help', 'copyright', 'credits' or 'license' for more information.
>>> import WebGui
```

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DEMO 02

Making the Weather Forecast in 3D

3D Printing



- Not that many years ago having your own colour printer was the stuff of dreams
- Nowadays you can buy them for next to nothing
 - Although the ink is always very expensive

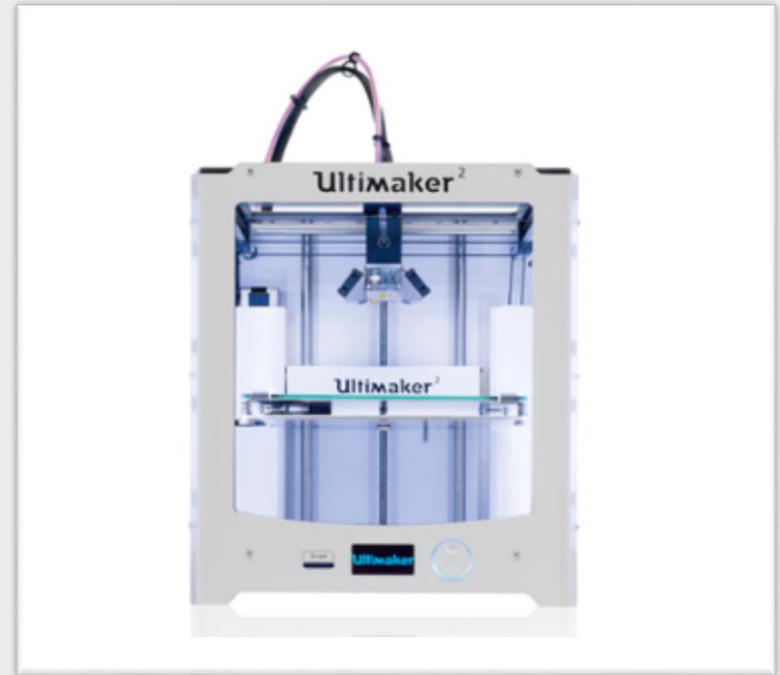
3D Printing

- Printing in 3D might seem as far fetched as everyone owning their own colour printer, or TV camera, did a few years ago
- The technology is now becoming almost mainstream
- We can print cheaply enough, and in sufficiently strong materials to make the technology viable



Uses for 3D Printing

- Rapid prototyping of designs
 - Prove that a physical design works as expected
- Short production runs of components
 - It may be uneconomical to mass produce the item
- Print things that can't be made any other way
 - Can print objects “inside” each other

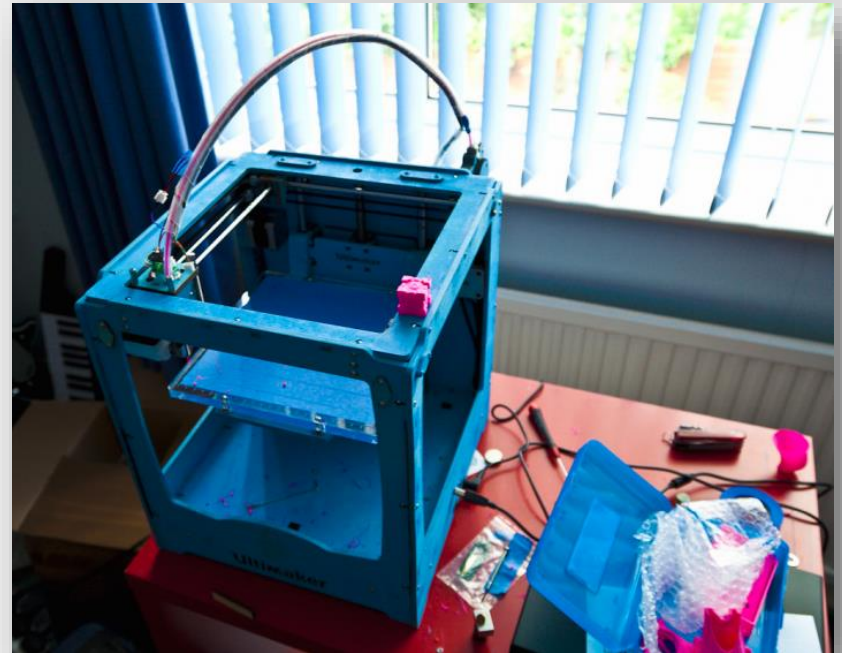


3D Printing Technologies

- There are lots of ways to print in 3:
 - Selective Heat Sintering
 - Heat up powdered plastic so it melts and fuses together and forms hard objects
 - Digital Light Processing
 - Shine a UV light onto liquid plastic which makes it harden
 - Fused Deposition Modelling
 - Lay down layers of material which is extruded onto a flat bed
- Each has its advantages and disadvantages
 - I don't think any of them are ready for prime time yet

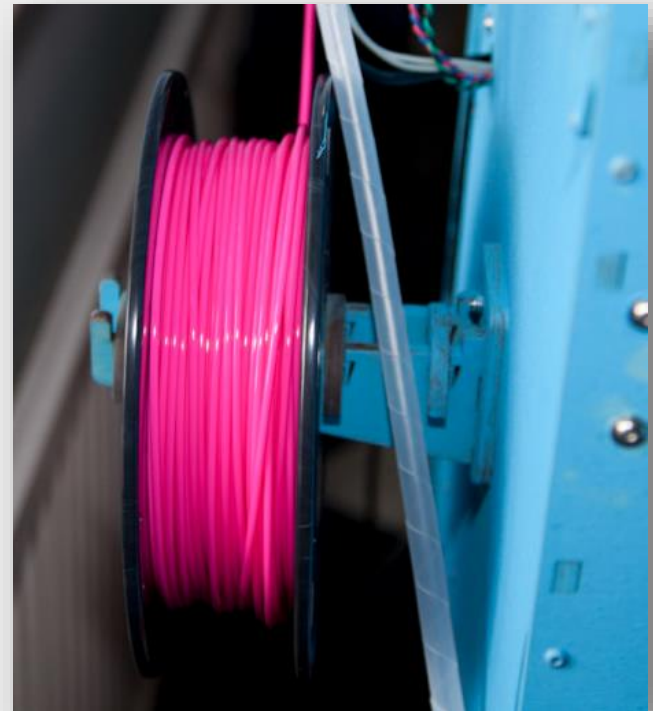
Introducing Una

- Una is myFDM 3D printer
- She prints by “knitting” together a continuous hot plastic fibre to make solid objects
- She is a bit temperamental, but when she is in a good mood she can print some amazing stuff



Raw Materials

- You can print on ABS or PLA types of plastic
- PLA is biodegradable and melts at a lower temperature
- It is supplied as a 3mm wide filament strand which is fed into the machine from a roll



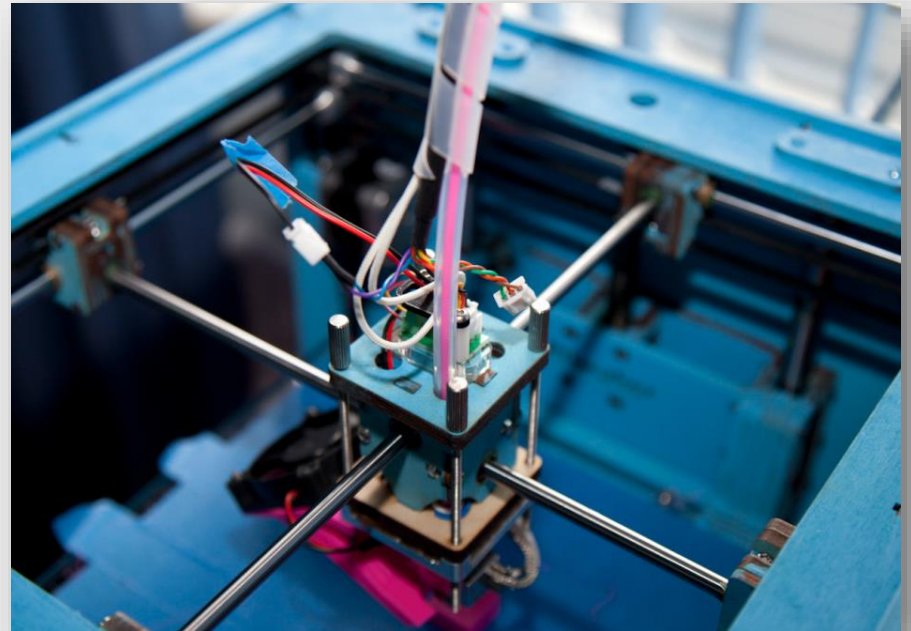
Feeding Plastic

- The drive motor pushes the plastic fibre into the clear tube towards the print head
 - This is called the “Bowden Tube”
- At this point the plastic is still solid
- Note that one of the gears is made of wood....



The Print Head

- The print head is driven left and right by stepper motors
- These allow very precise positioning
- The plastic fibre is fed through the Bowden Tube into the print head at the top



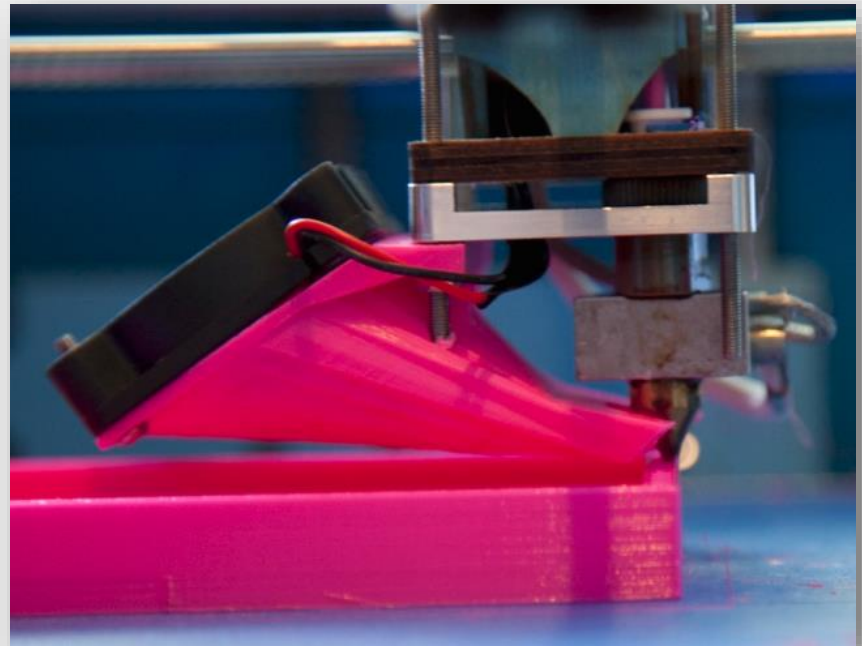
The Print Head

- The shiny metal block in the middle contains a heater that melts the plastic
- It then comes out of the print nozzle at the bottom and lands on the thing Una is building
- Una builds each layer in turn



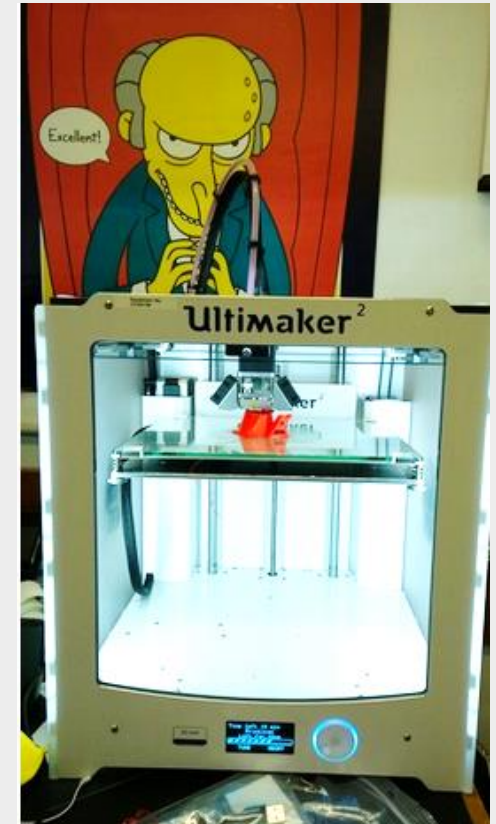
Printing in action

- Here Una is building the side of a box
- The hot plastic is coming out of the brass nozzle
- The fan on the left is cooling it down so that it sticks to the previous layer



Departmental Ultimakers

- The department now has 3 Ultimaker printers
- They are used to underpin research and industrial work
- If you have an idea for something you might like to print, let us know



FDM Printing

- The great thing about FDM printing is that it works
- There are a few less great things though
- Models are built up of layers, which means that things like overhangs are hard for printer to produce
 - You can print at an angle of up to around 45 degrees before things start to go badly
- The material itself is prone to shrink as it cools, leading to warping of flat surfaces
- You can only print in one colour at a time

3D Printing Workflow

- Create the design using a 3D package
 - FreeCad, Autodesk 123D, Sketchflow all work well
- Export to an STL file
 - This contains a mesh that describes the object to be printed
- Slice the mesh to produce a “GCode” file that describes the printer path
 - I use a program called Cura to do this
- Send the design to the printer

3D Printing and Fun

- You can generate the designs (and even the GCode files) programmatically
- The printer firmware can also be reprogrammed
- Many printer designs and control software are open source, so you can fiddle with them
- You can also use a 3D printer to print parts to make another 3D Printer
 - You can also print extra parts for your printer (or printers for other people)

3D Printing and the Future

- Selling 3D printing technology as something which is here now is being wildly optimistic
 - Although they are great fun to tinker with and for prototyping at a very low cost
- It is pretty much certain that our future will contain 3D printers of some kind
 - Although I'm not convinced that the current generation of technology will be how they end up working
 - They need to get a lot cheaper
 - They need to be able to print in colour
 - They raise a whole new set of copyright issues

Useful Stuff

- 3D Printers and Cura
 - <http://www.ultimaker.com/>
- Free 3D Design and Scanning Tools
 - <http://www.sketchup.com>
 - <http://sourceforge.net/projects/free-cad/>
 - <http://www.123dapp.com/>
- Things
 - <http://www.thingiverse.com/>
- Open SCAD
 - <http://www.openscad.org/>
 - <http://openjscad.org/>

Also available....

www.robmiles.com