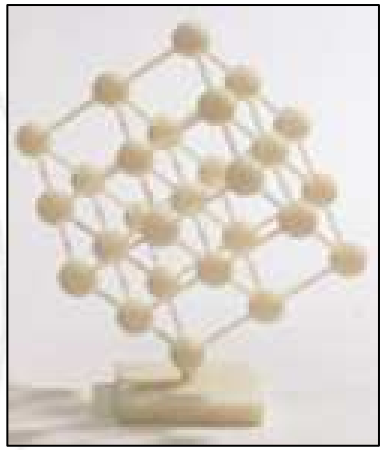
University of Pavia
Dept. Of Clinical and Surgical Sciences

3D Printing Technology

- Friday Meeting -



June 7th, 2013 – DICAr, Aula MS1

Stefania Marconi

Outline

- 3D printing technology overview
- Objet 30 Pro 3D printer
- Purposes
- Possibilities

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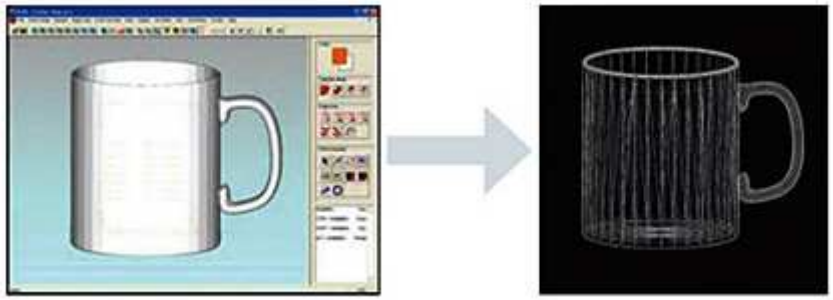
3D Printing - Origin

- **1981 – First article about 3D printing technology** (Hideo Kodama of Nagoya Municipal Industrial Research Institute)
- **1984 – First functioning 3D printer** (Charles Hull, inventor of stereolitography, 3D System co-funder)
- **1990s – Introduction of new printing technologies**, like Fused Deposition Modeling and Selective Laser Sintering
- **2000s – Introduction of new printing materials** (biocompatible materials, metals, wax and even cells)
- **Last 3 years –** great diffusion of 3D printing technology

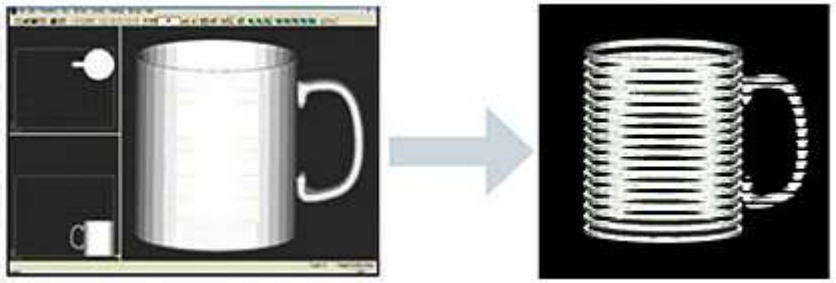
3D Printing – General Principles

Additive manufacturing → Creates objects through a sequential layering process

Step 1 – From CAD model to .STL file)



Step 2 - Virtual slicing

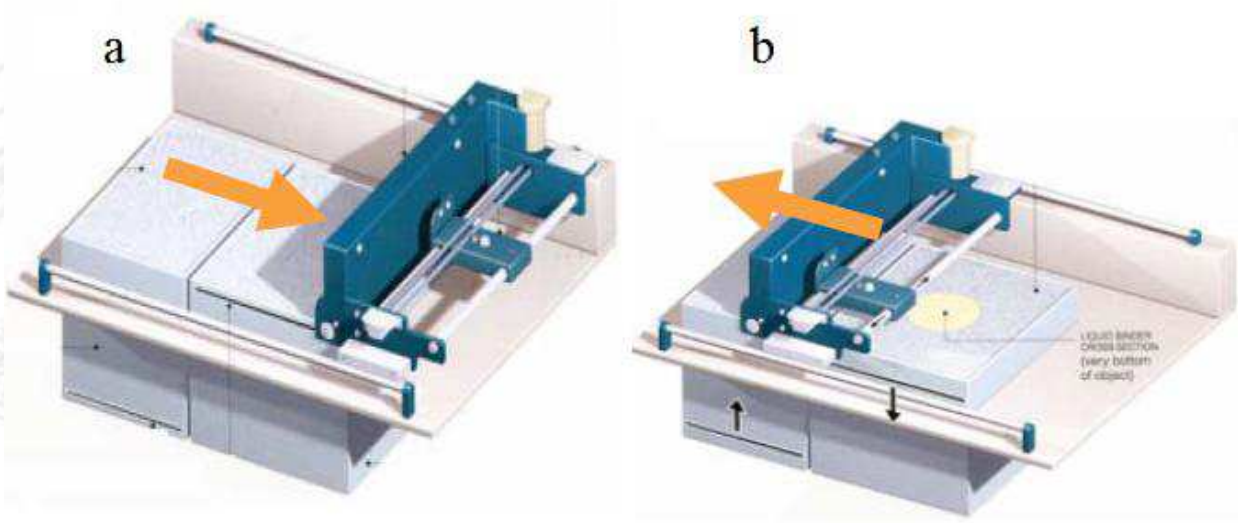


Step 3 - Printing

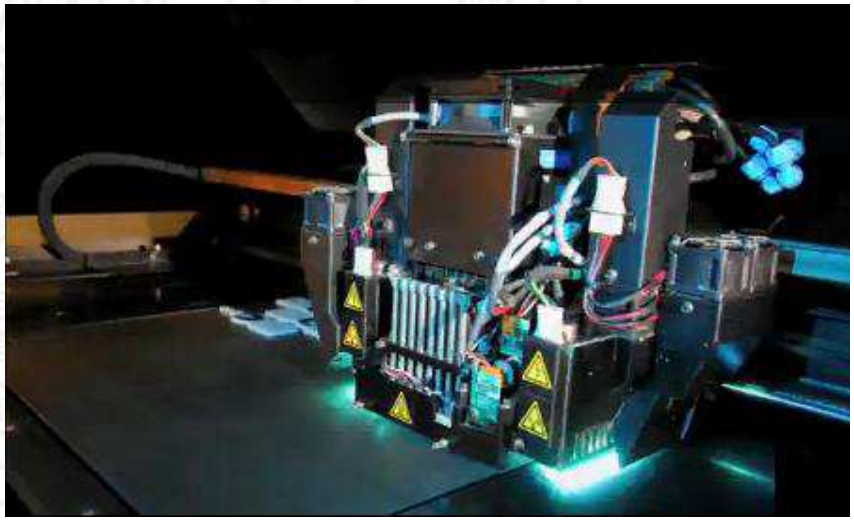
3D Printing – General Principles

Printing: 3 steps

1) Printing head deploy a layer of material
2) Layer is cured
3) The printer tray moves down



Printing technologies **differ in the way layers are deposited** or cured



3D Printing – Technologies 1

- **SLA – StereoLitography Apparatus**
  - **Material**: liquid material
  - **Building**: UV laser beam that traces each slice of the object on the surface of this liquid, causing a very thin layer of photopolymer to harden
- **Material Extrusion: FDM – Fused Deposition Modeling**
  - **Material**: semi-liquid material (usually thermoplastic)
  - **Building**: material is deposited from a computer-controlled print head
- **SLS - Selective Laser Sintering**
  - **Material**: fine layer of powder (wax, polystyrene, nylon, glass, ceramics, stainless steel, titanium, aluminium)
  - **Building**: a laser selectively fuse a layer of granules together

3D Printing – Technologies 2

- **Material Jetting**
  - **Material**: photo-polimeric material
  - **Building**: object layers are created by emitting liquid photopolymer from a print head (like inkjet printers). The layer is cured using UV light.

- **Polijet technology (Objet Connex printers)**
  - **More than one** photo-polimeric material at a time
  - **Digital materials**:
    - Set resulting object mechanical properties
    - Print two different materials at a time

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Objet 30 Pro 3D printer – General Information

-**Build size:** 294 x 192 x 148.6 mm

- **Layer thickness:** 28 microns (16 microns for transparent material)

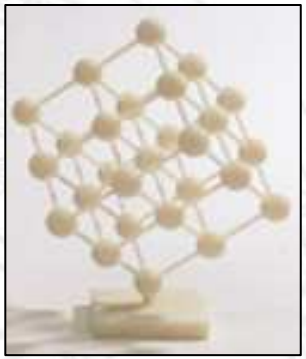
- Building technology:
  - **material jetting**
  - printing **one material at a time**

- The model grows within a **support material:** gel-like material, easily removable with water-jet cleaning machine

-The 3D printer software selects the **best slicing and building orientation**
  - ensures the best model quality
  - allows the saving of support material

Objet 30 Pro 3D printer – Printing process

7 printing materials



- **Rigid opaque materials:**
  - White (VeroWhitePlus)
  - Black (VeroBlackPlus)
  - Blue (VeroBlue)
  - Gray (VeroGray)

- **Transparent material** (VeroClear): a nearly colorless material (visual simulation of transparent thermoplastic such as PMMA)

- **High Temperature material** (RGD525): for advanced functional testing, hot air/water flow, static applications

- **Polypropylene-like material** (DurusWhite): for snap fit applications

Objet 30 Pro 3D printer – Main Interesting Features

Why this one?

- **Transparent material**: very useful, expecially for building anatomical models

- **High printing accuracy** (28 microns): allows high surface smoothness → very important for fluidodynamic analysis

- **Cost!**

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Purposes

What we have already planned to do?

1) **Vascular models,** for in vitro simulation purposes

2) Models of the **pancreas,** for pre-operatory planning purposes

3) **Biomedical devices models**, for new devices development and pre-production studies

Purposes – Vascular Models

Purpose: get a physycal model of the patient specific aortic arch or other vascular districts and perform in-vitro simulation using the hydraulic circuit.

1) Start from angio-CT, CT or MRI images and get the **patient specific vascular anatomy**

2) Get a **.STL model of the wall** of the vascular structure

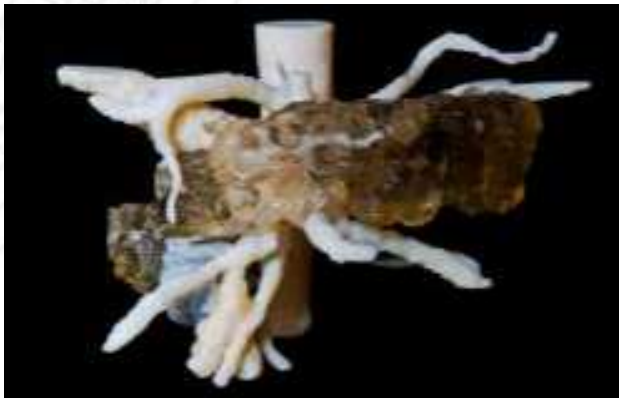
3) Print the model

- Print a **rigid model** using transparent material
- Get a **deformable model** in silicon
  - Get a virtual **negative model** of the anatomy (.STL)
  - Print it in rigid plastic material
  - Strain silicon in the negative model (**vacuum chamber** to get off air bubbles)
  - Remove the plastic negative model

Purposes – Pancreas Models

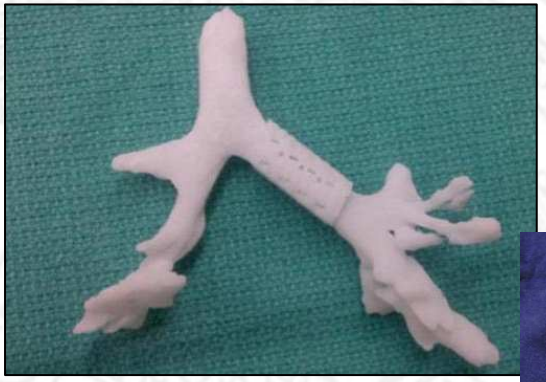
Purpose: get a physical model of the pancreas, peri-pancreatic vessels and tumor mass.

1) Start from CT images and get the **patient specific anatomy**
2) Get the **.STL model of the 3 structures**: pancreas, vessels and tumor
3) Create a **cut plane** in the pancreas head and insert pins to get an assemblable model → to allow inserction of the tumor mass model
4) Print the structure
   - Pancreas in **transparent material**
   - Vessels and tumor in **rigid plastic material**



Purposes – Biomedical Devices

Purpose: get a physical model of the design device, for testing or just visualization purposes



1) Start from **CAD model**
2) Get the **.STL model**
3) Just print the model

Physical object can be used in:

- Pre-production → Rapid prototyping
- Full-scale production → Rapid manufacturing

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Purposes – Biomedical Devices

What we can do with the 3D printer?

- Print each CAD model that meets **maximum building tray dimensions**

- Realize models even of high **complexity**

  - 28 microns resolution allow the printing of functioning mechanisms

Possible employments: rapid-prototyping services, small architectural plastics, and....

Thanks for your attention