Interaction and Visualization in 3D space

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Flavio Bertini
flavio.bertini2@unibo.it

Department of Computer Science
and Engineering

Syllabus

- Traditional 2D devices & problems
- New 3D devices: interaction and visualization
- Application examples
- 3D interaction and visualization in 3D modelling

Traditional devices

- It is a typewriter-style device (teleprinters and keypunches).
- It is, to date, the most commonly used and most versatile device used for human input.

- It is a pointing device that convert a two-dimensional motion in a position into the display.
- It represents a pillar of the graphical user interface paradigm.

- To control a computer through icons and pointing devices.
- There are several windowing systems based on WIMP "window, icon, menu and pointing device".

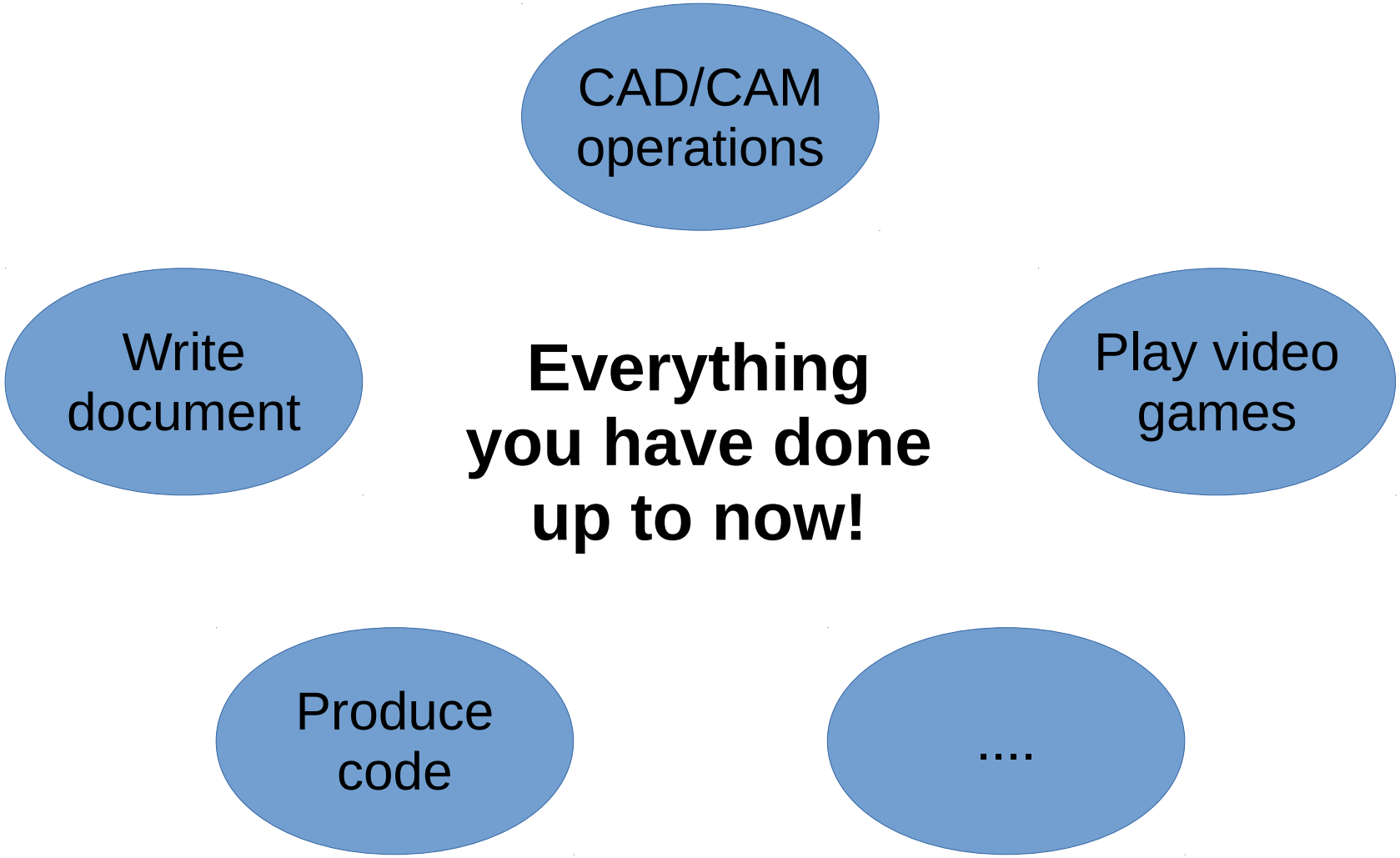
Some other devices

Joystick

Joypad

Trackpad

What can you do?

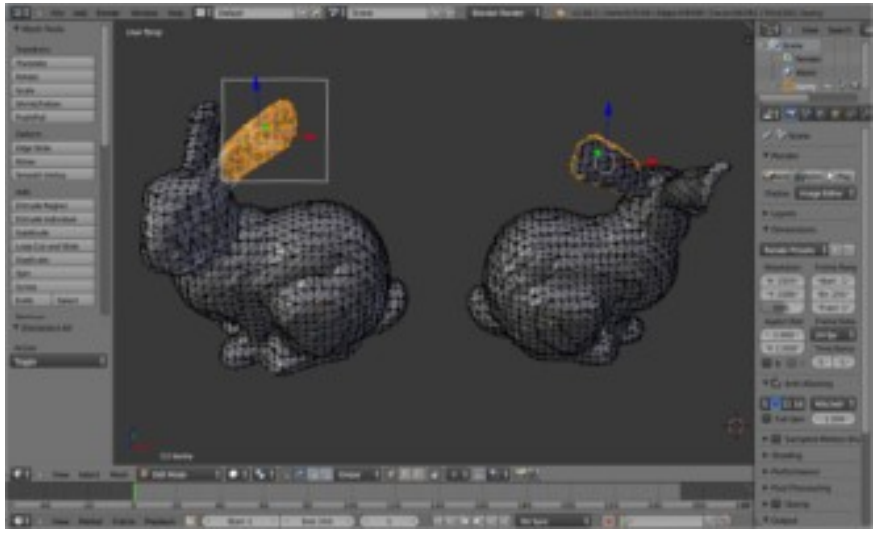


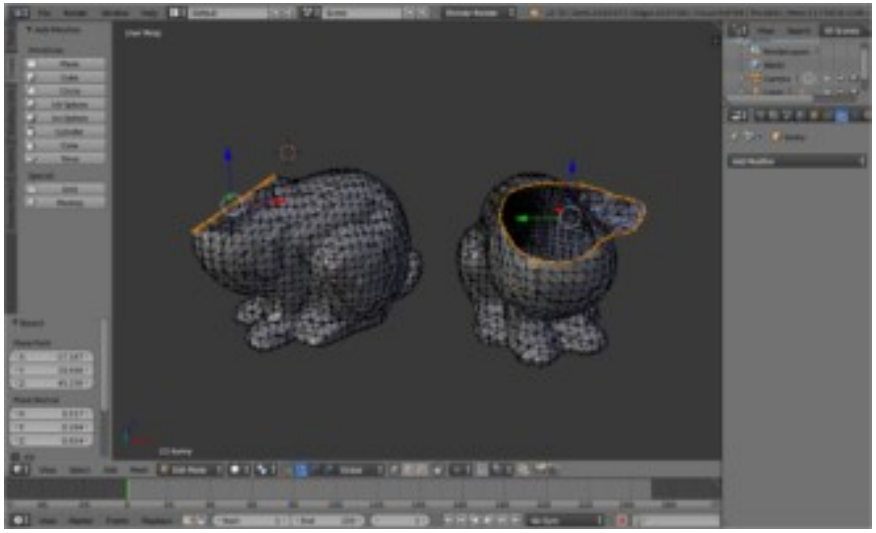
What cannot you do?

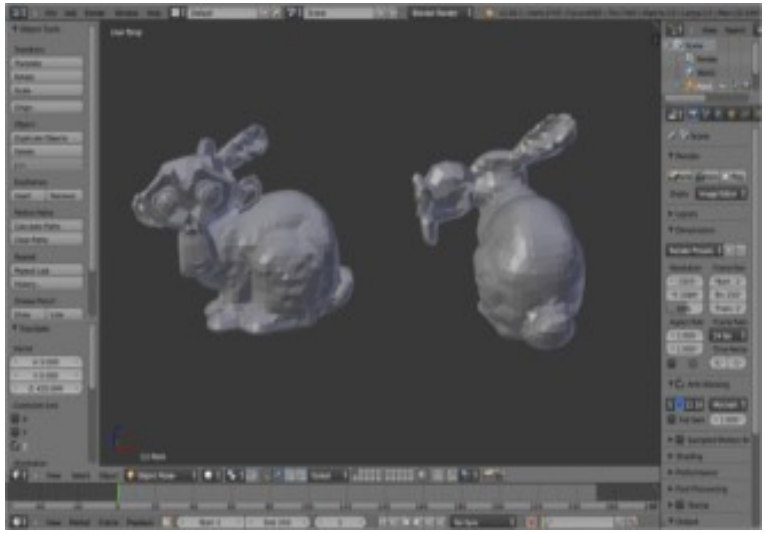
Maybe nothing
but …

- There are a plenty of troubles with 3D operations in CAD/CAM systems.
- You do not have any cue to perceive depth.
- The user ability is directly proportional to the system complexity.
- New paradigms lead to new users.

One more example: complexity







New devices for interaction

Fin

Ring

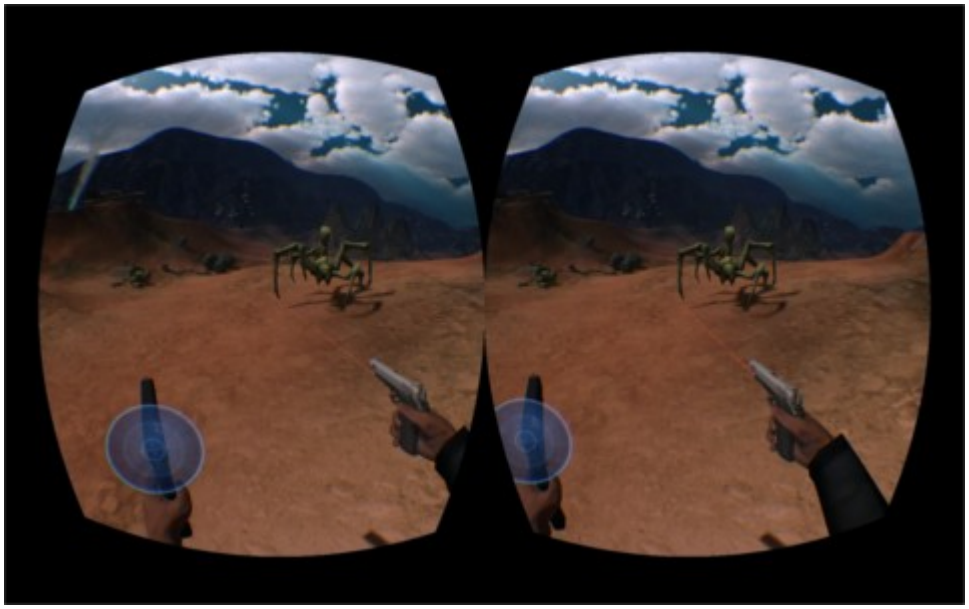
MYO

Physical & Optical Sensors
or
Werable device

- Motion sensing input devices.
- They enables users to control and interact with their console or computer using gestures.
- They can fuse information deriving by inertial sensors and image produced by a camera.

New devices for visualization

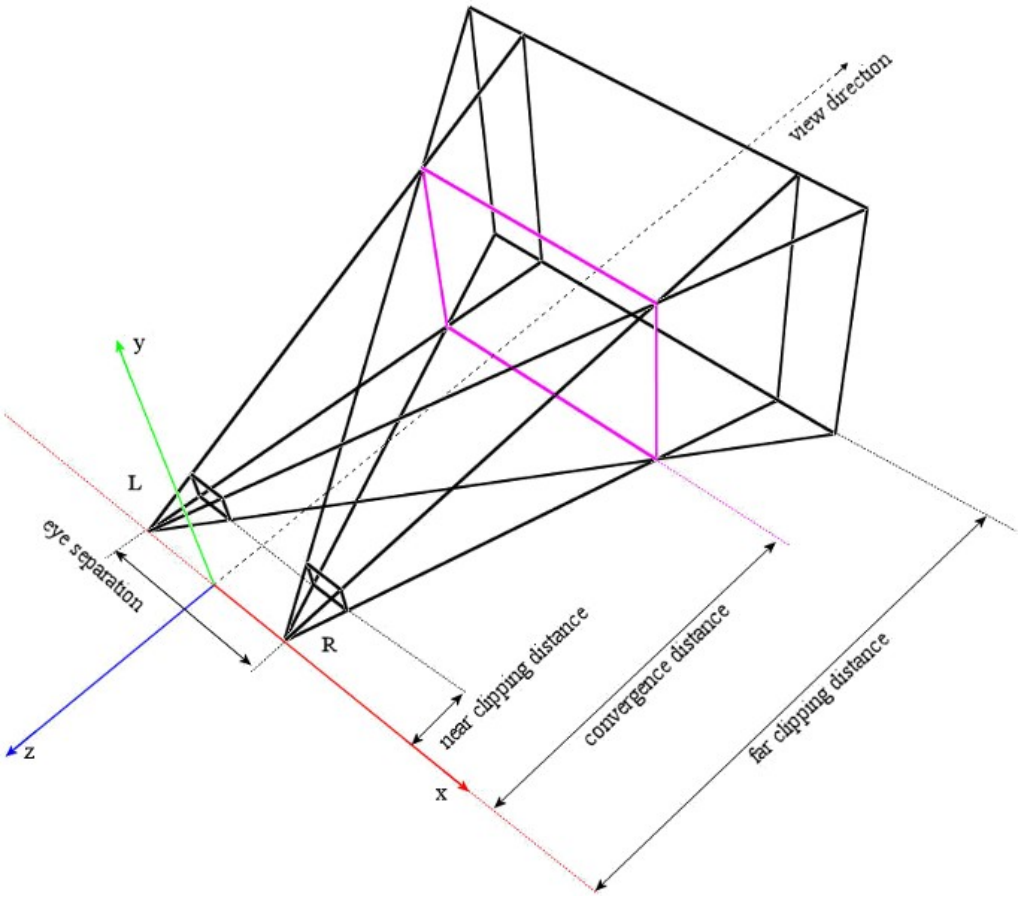
Oculus Rift

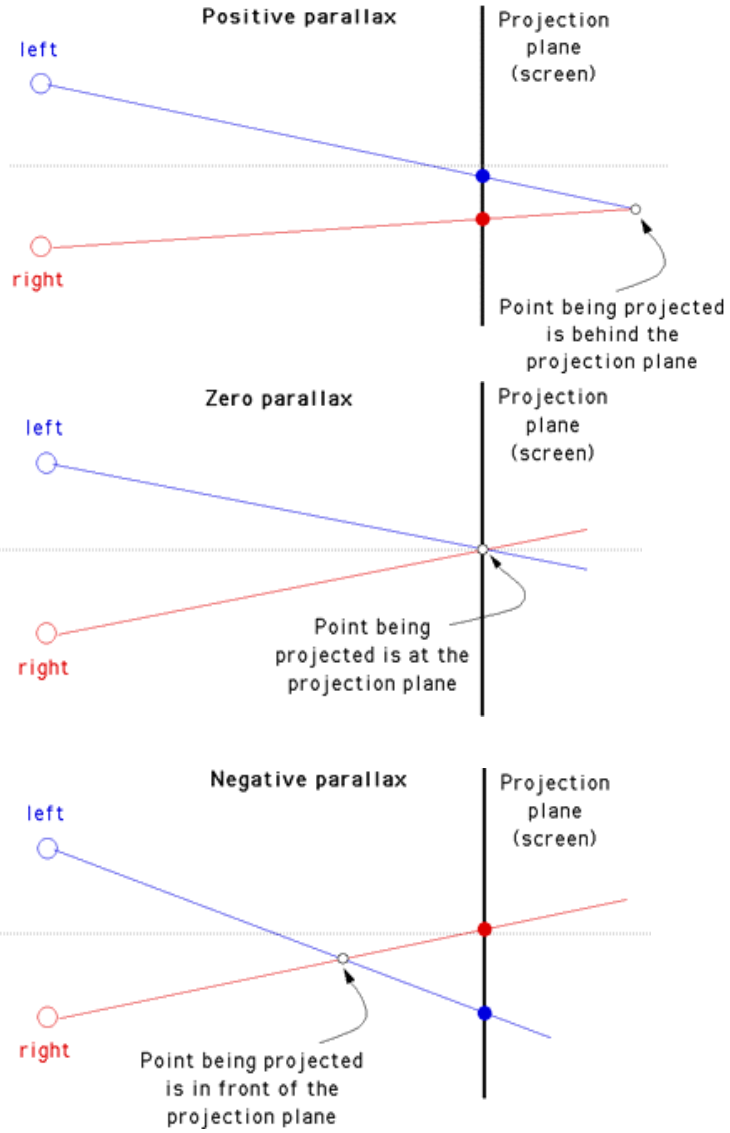


Stereoscopic vision

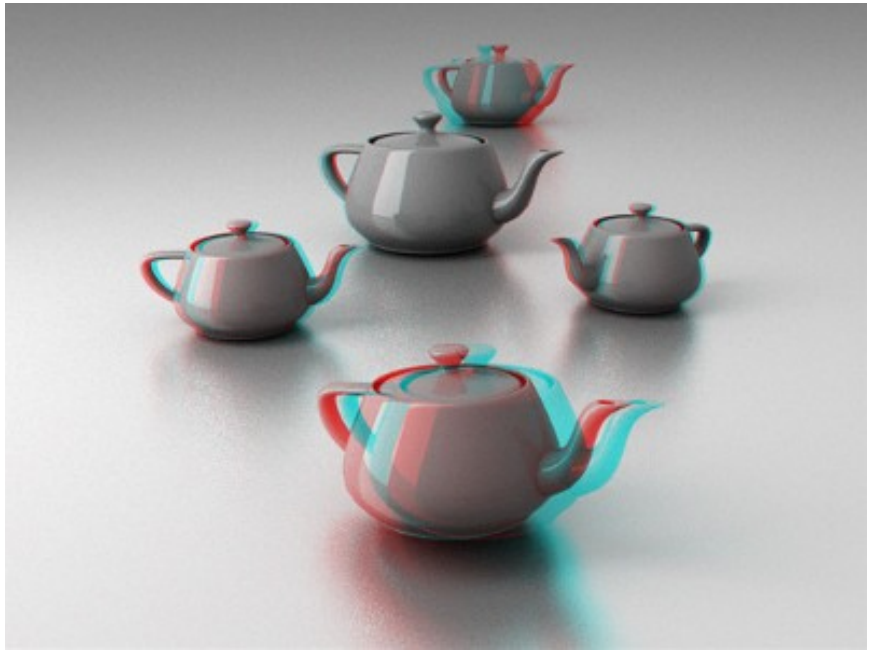
- This technique provides **two different images** of a unique scene from a **different perspective**, one for each eye.
- The stereoscopic images allow viewers to perceive depth through various cues (eg.: stereo parallax, accommodation and depth of field).
- The main drawback of this kind of displays is known as **accommodation-convergence mismatch**.

Stereoscopic theory in a nutshell





Stereoscopic vision: anaglyph



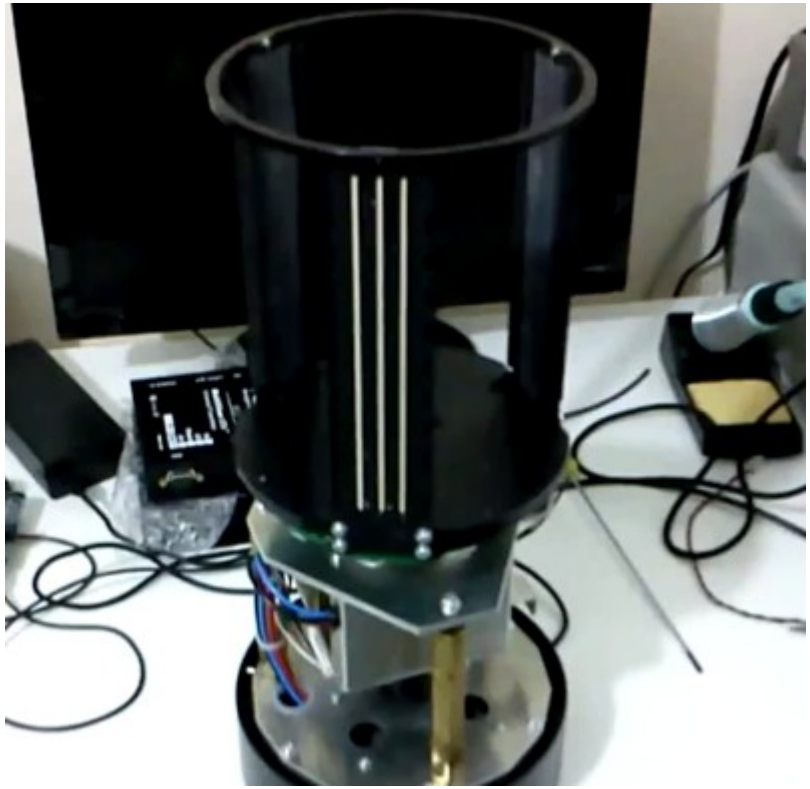
Stereoscopic vision: polarized images

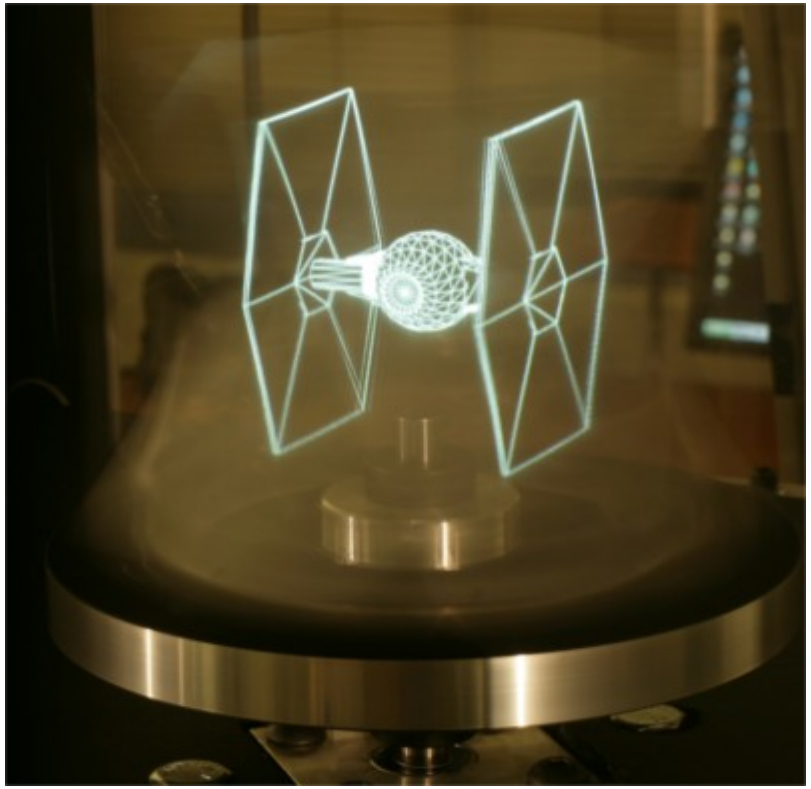
Stereoscopic vision: field sequential

Volumetric display

- This technique provides only one single image scattering out the 3D space with points or planes of light.
- The volumetric displays provide all depth cues of a real 3D scene. They have a wide field of view however the scene is intrinsically limited to the volume of the display.
- There is no mismatch between accommodation and convergence but they cannot provide any occlusion relationship among objects or parts of the same object.

Volumetric display: an example

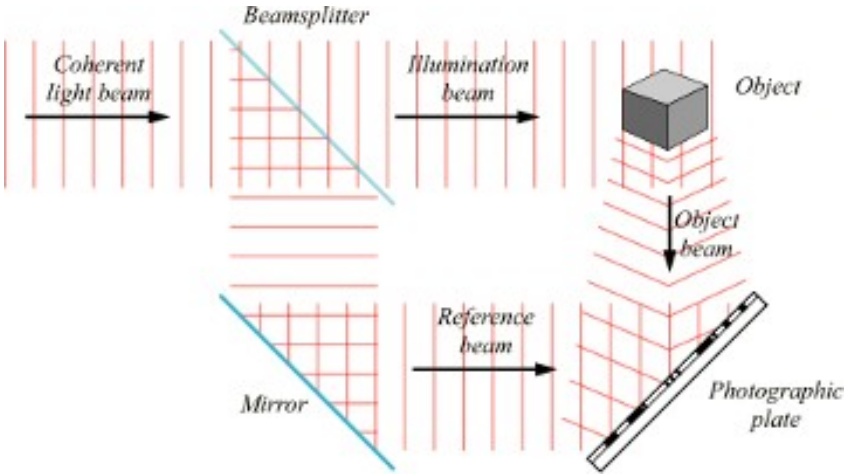




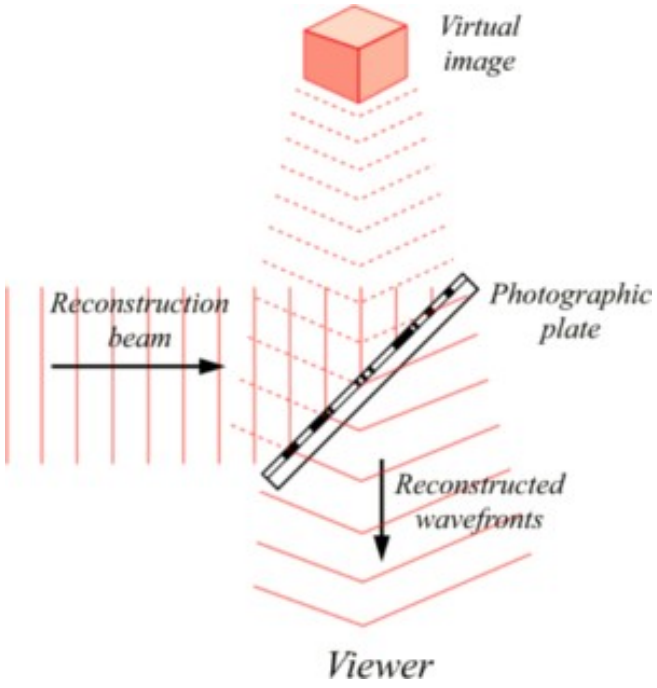
Holographic display

- A hologram is an interference pattern between two coherent light beams; the reference beam codes the object information as the object beam carries the depth or phase information.
- They do not suffer from the mismatch that is inherent in stereoscopic displays, provide all depth information and cues and they are autostereoscopic.
- They can be viewed from multiple perspective without using special goggles, even though they can provide extremely realistic, high resolution and fullcolour images.

Holographic display: theory

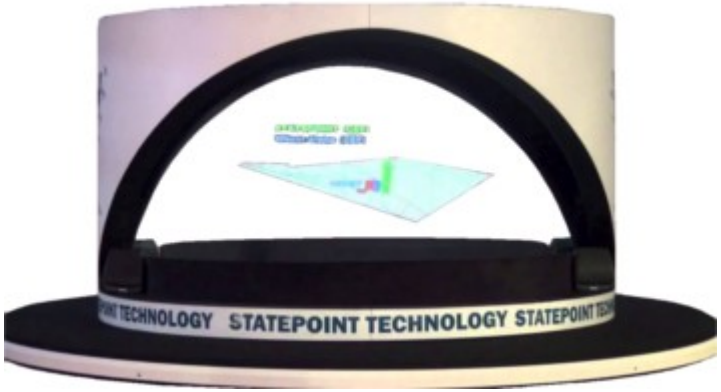


Creation



Utilization

Holographic display: an example



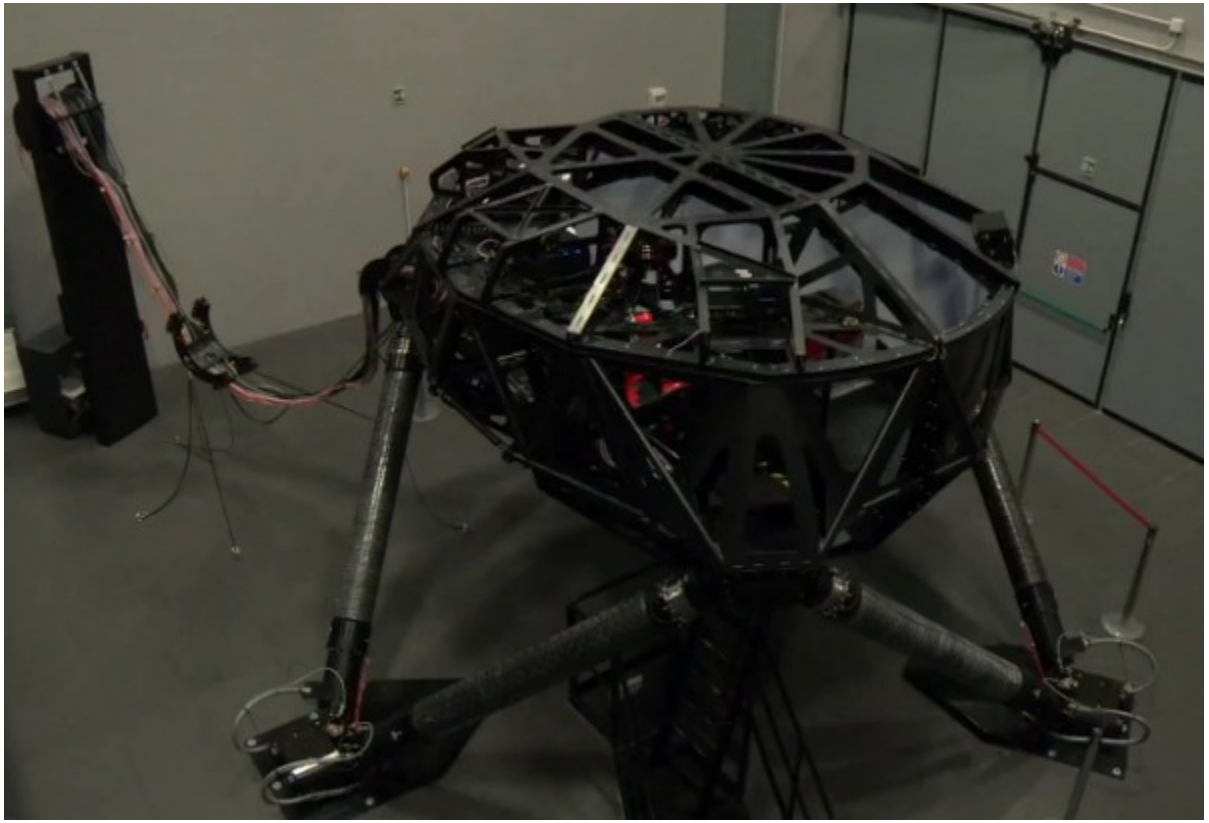
What can you do?

- You can interact with the console or the computer in a 3D way that it has never been possible before.
- The machine becomes able to detect the object in the space with a good approximation.
- You can have a better cue to perceive depth.
- A complex activity can be encoded with gesture.
  (eg: mv [OPTION]... [-T] SOURCE DEST drag&drop)
- Virtual Reality is fused with Real World to produce the Augmented Reality.

What cannot you do?

- The optical device cannot see behind the corner!
- The visualization system cannot reproduce behind the corner!
- You must align the vision system and the interaction system ... and hope that the first one does not interfere with the second or vice versa.
- You might have several problems with the light (eg: reflection).

Examples: Ferrari F1 simulator



http://www.cxcsimulations.com/news/formula-1-simulator/

Examples: home gesture recognition

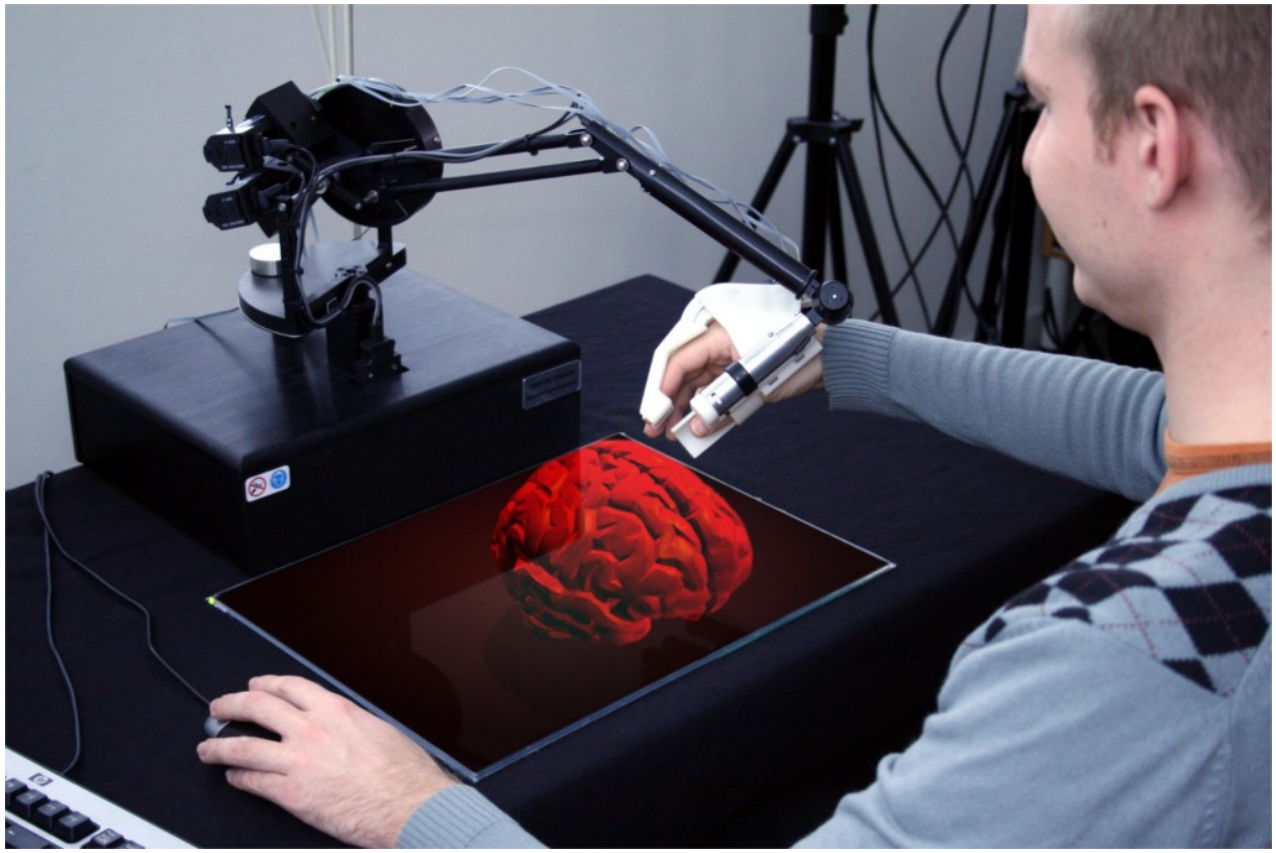
wisee

"*Whole-home gesture recognition using wireless signals*"
Qifan Pu, Sidhant Gupta, Shyam Gollakota and Shwetak Patel.
In Proc. of the 19th IC on MCN. 2013 ACM.

Examples: hand gesture recognition

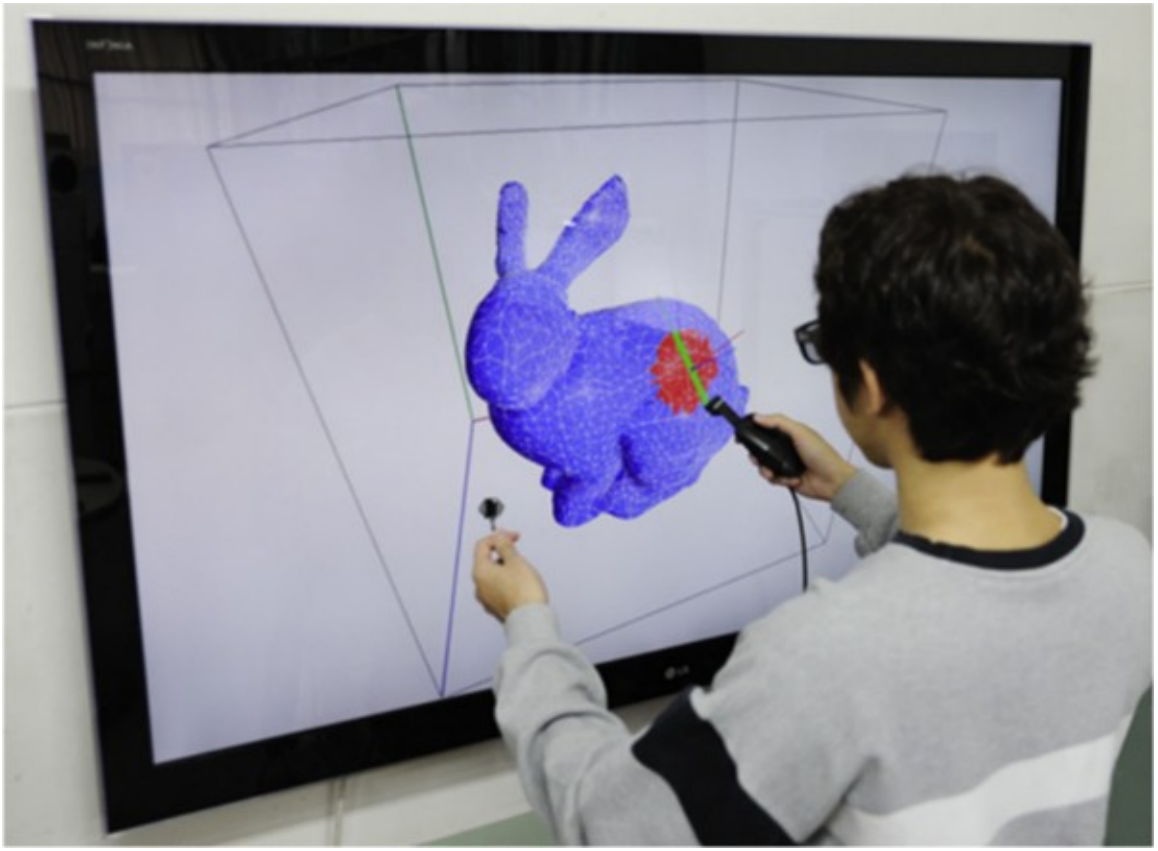
"*Real-time hand-tracking with a color glove*"
Wang Robert Y. and Jovan Popović.
ACM Transactions on Graphics, 2009.

Examples: haptic interaction



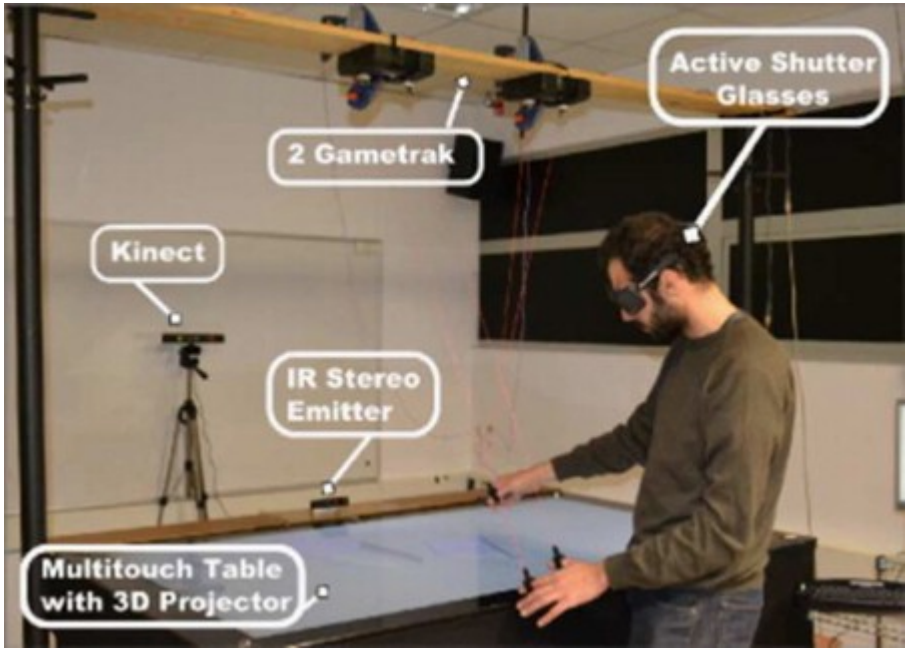
"*Physically Co-Located Haptic Interaction with 3D Displays*"
Pontus Olsson, Fredrik Nysjö, Stefan Seipel and Ingrid Carlbom.
In Proc. Haptics Symposium (HAPTICS), 2012 IEEE.

Examples: shape modeling



"SPACESKETCH: Shape modeling with 3D meshes and control curves in stereoscopic environments"
Nam Sanghun and Youngho Chai.
Computers & Graphics, 2012.

Examples: 3D modelling



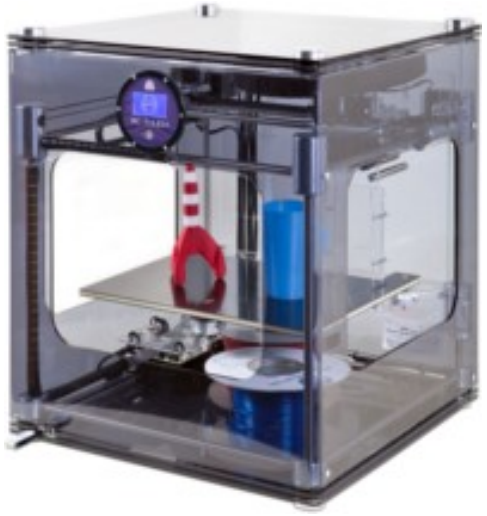
"*Mockup Builder: 3D modeling on and above the surface*"
Bruno R. De Araújo, Géry Casiez, Joaquim A. Jorge and Martin Hachet. Computers & Graphics, 2013.

Is the 3D modelling for everyone?

- Would an user without specific experience be able to use 3D modelling tools?
- Are the hardware and software solutions currently available suitable to be used by a non-professional user?
- Can we consider the absence of the third dimension in the common display and interaction system as a real need?

Printing Evolution

Almost **everybody** knows how to use it

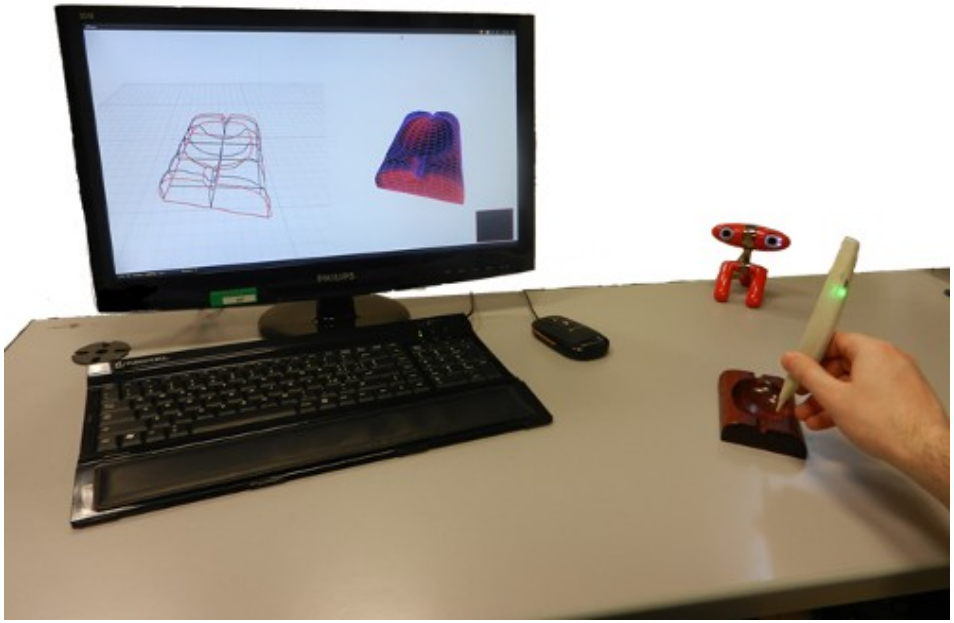


Almost **nobody** knows how to use it

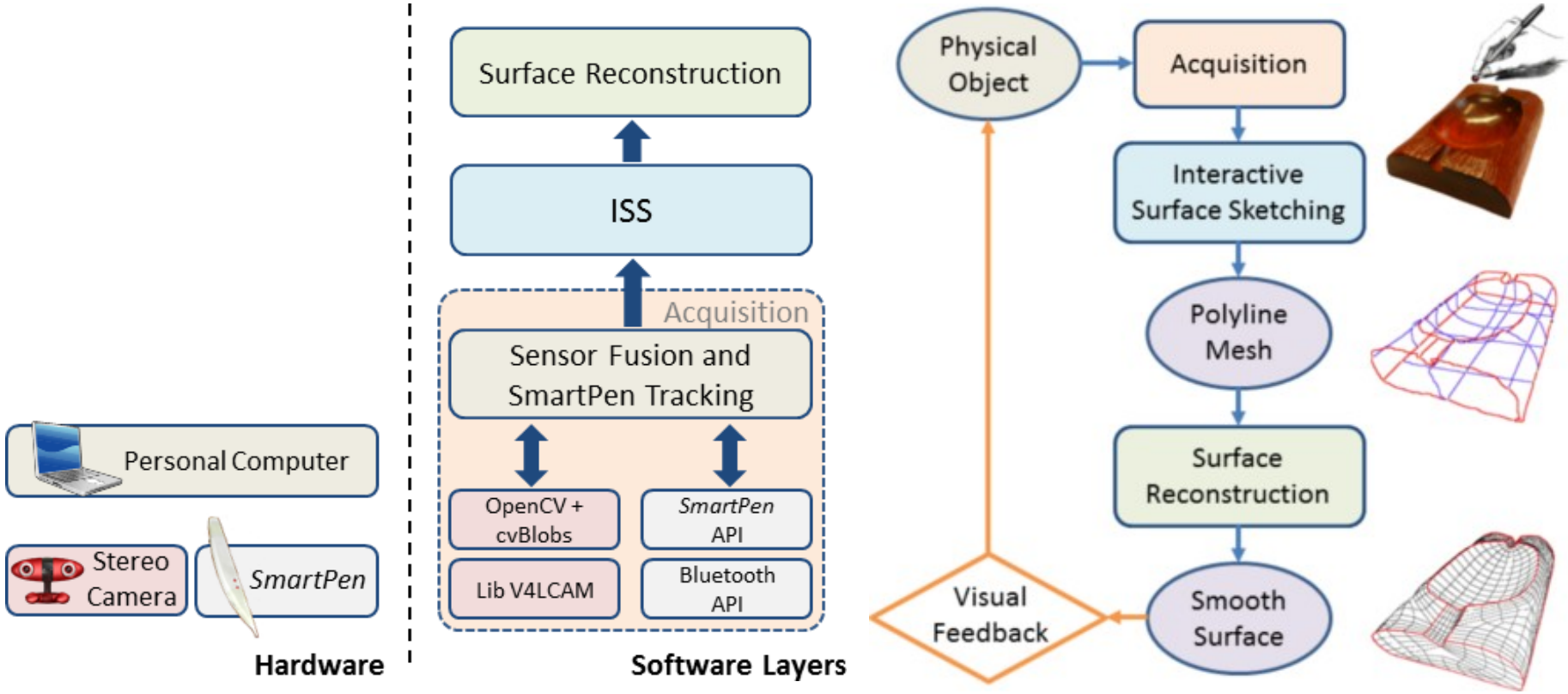
3D modelling in a 3D environment

- **Sketch-based modelling** - The concretization of an idea into a 3D virtual model: a tool that allows you to simply draw in the air just as you would on paper.
- **Interaction and visualization** - The navigation and the interaction in a 3D modelling environment: how gestures and movements can be exploited to explore and operate on the virtual model.
- **Advanced modelling operations** - The virtual model transformation: which operations we can integrate to modify the model, ensuring simple and effective functionalities.

A fast interactive reverse-engineering system

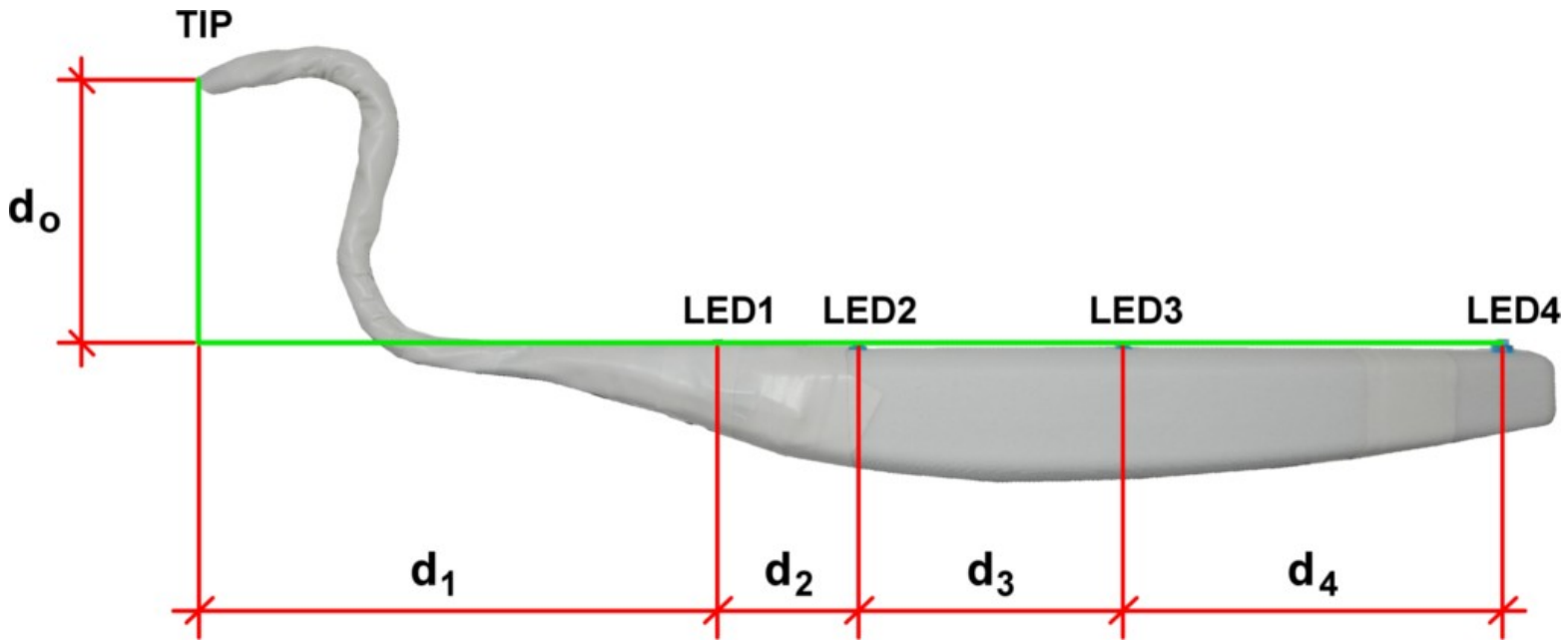


FIRES: hardware and software layers



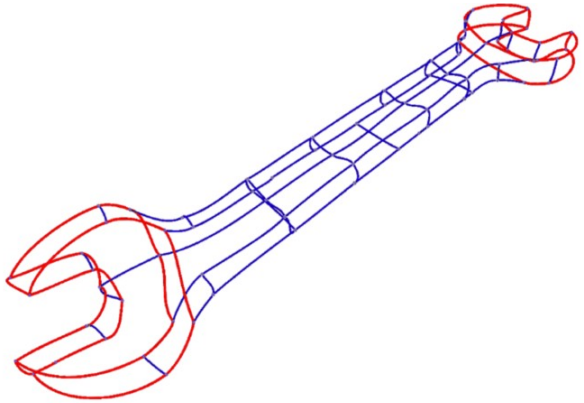
Occlusion problem

We introduced a bendable tip. The d_0 distance is employed to correctly translated the p_{tip} orthogonally to the v_{pen} direction using the yaw angle provided by the magnetic sensor.



Results: reverse engineering

original

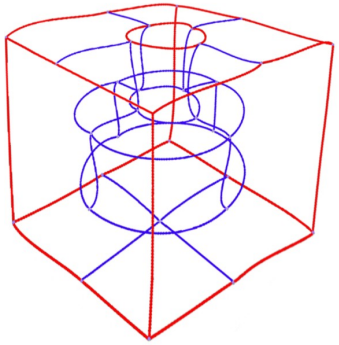


smooth

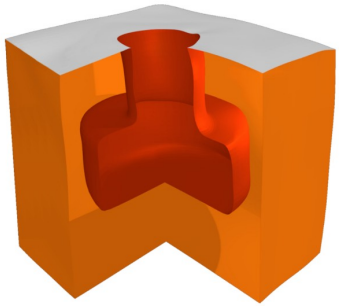
rendering

prototyped with a 3D printer

Results: concave objects

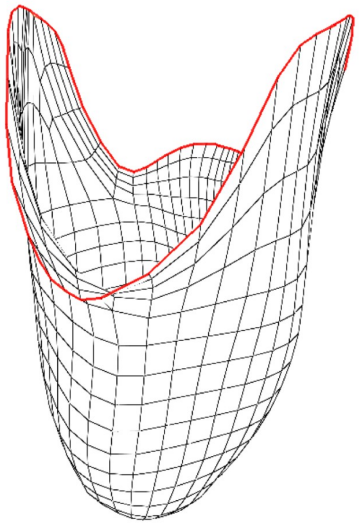


smooth

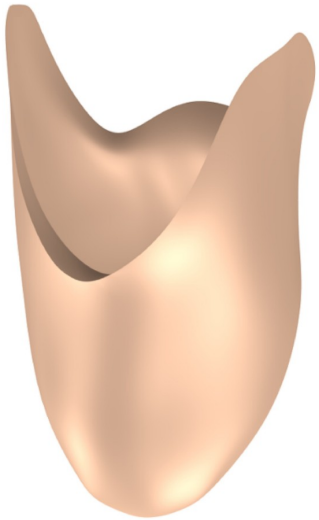


a section

original



wireframe

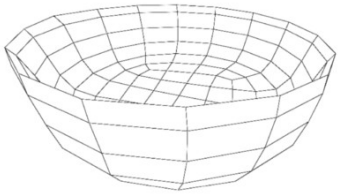


rendering

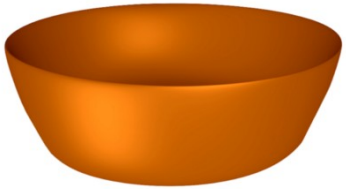
original

Results: freehand sketching

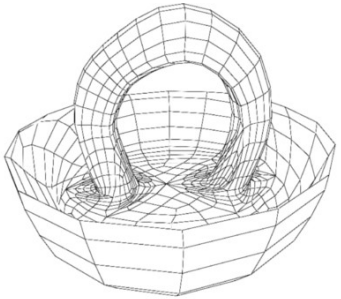
original

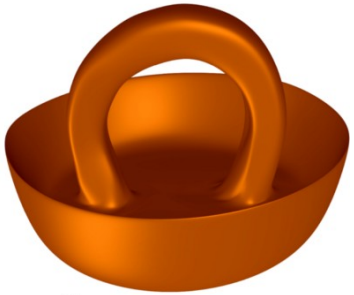


wireframe (restored)

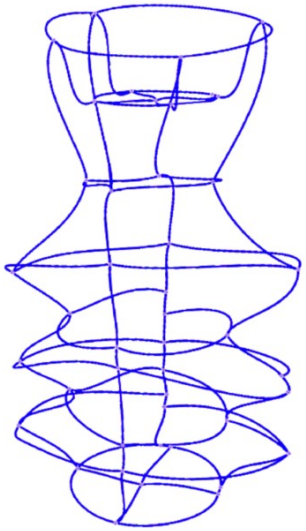


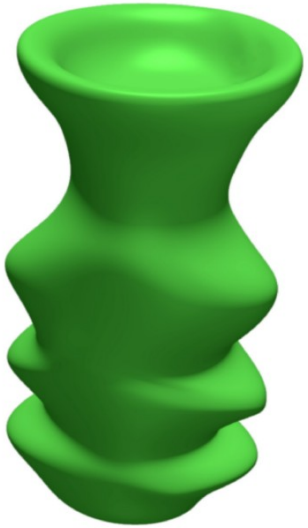
rendering (restored)





freehand handle





freehand vase

DEMO

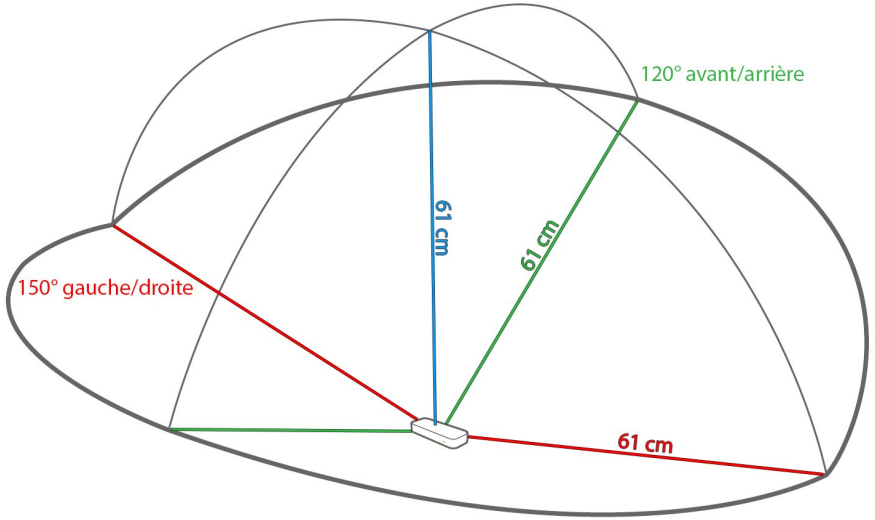
A 3D modelling environment

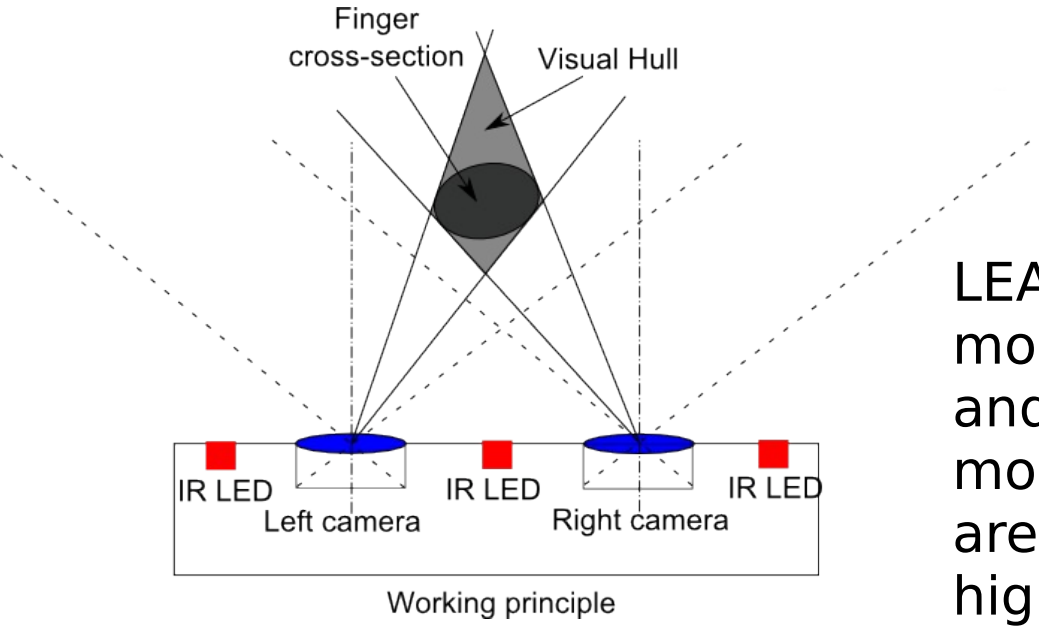
"*a 3D interaction is any interaction in which the user's tasks are performed directly in a 3D spatial context*"

Doug A. Bowman

There is not a general purpose solution and according to your goals you can test different combinations of 3D interaction and visualization methodologies. Nowadays, **optical tracking is best technological** solution that you can adopt to follow the user movements: hands, fingers and tools.

LEAP Motion device



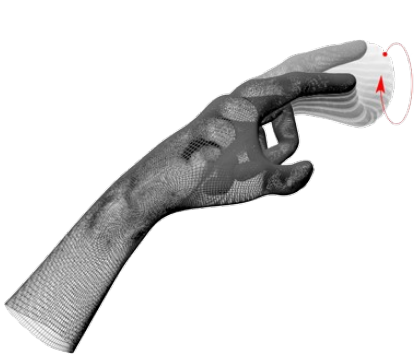


Working principle

LEAP Motion device uses two monochromatic infrared cameras and three infrared LEDs to monitor a roughly hemispherical area whose sizes are 610mm high, 150° wide and 120° deep.

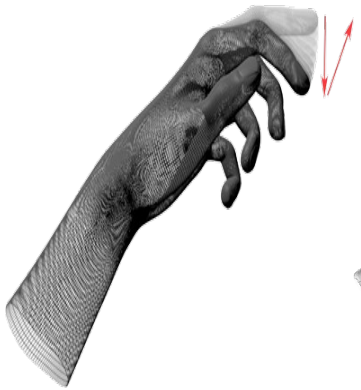
Gesture operations

The Leap Motion software can predict the positions of **fingers**, **hands** (arm and bone) and **pen-like tools**. Five fingers are always present for a hand. Hands can often cross over each other and still be tracked, in this case the controller estimates the position of the hidden hand.
It is able to decode **four different gestures**.

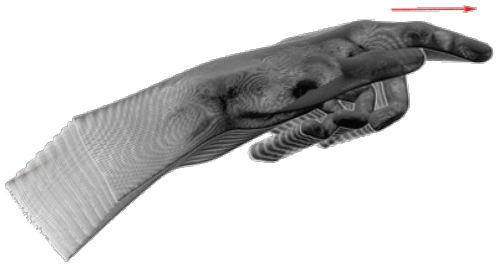


Circle Gesture

Swipe Gesture



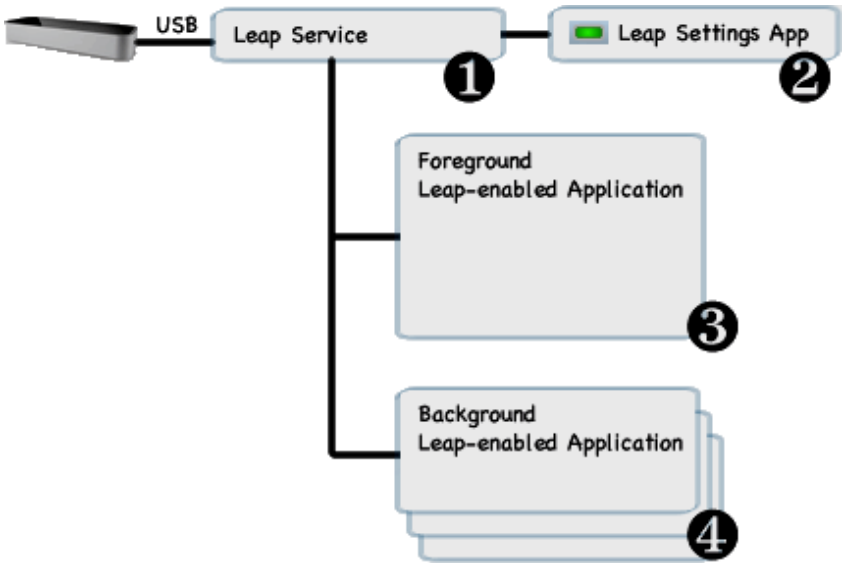
Key Tap Gesture



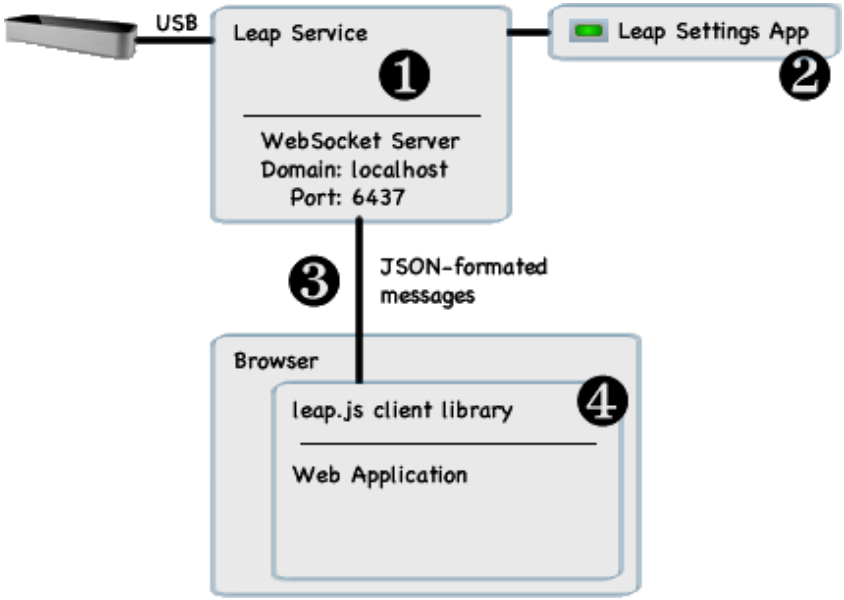
Screen Tap Gesture

SDK architecture & language

Native applications



Web applications



C++

C# and Unity

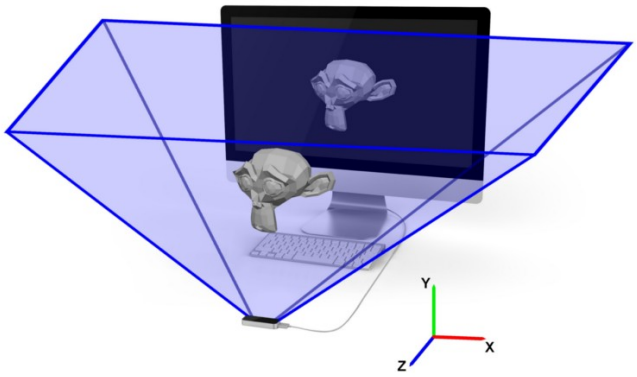
Objective-C

Java

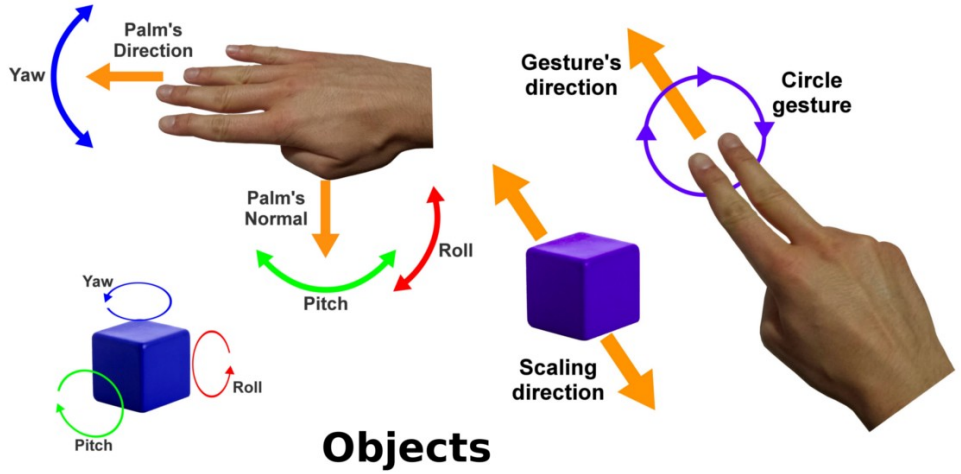
Python

JavaScript

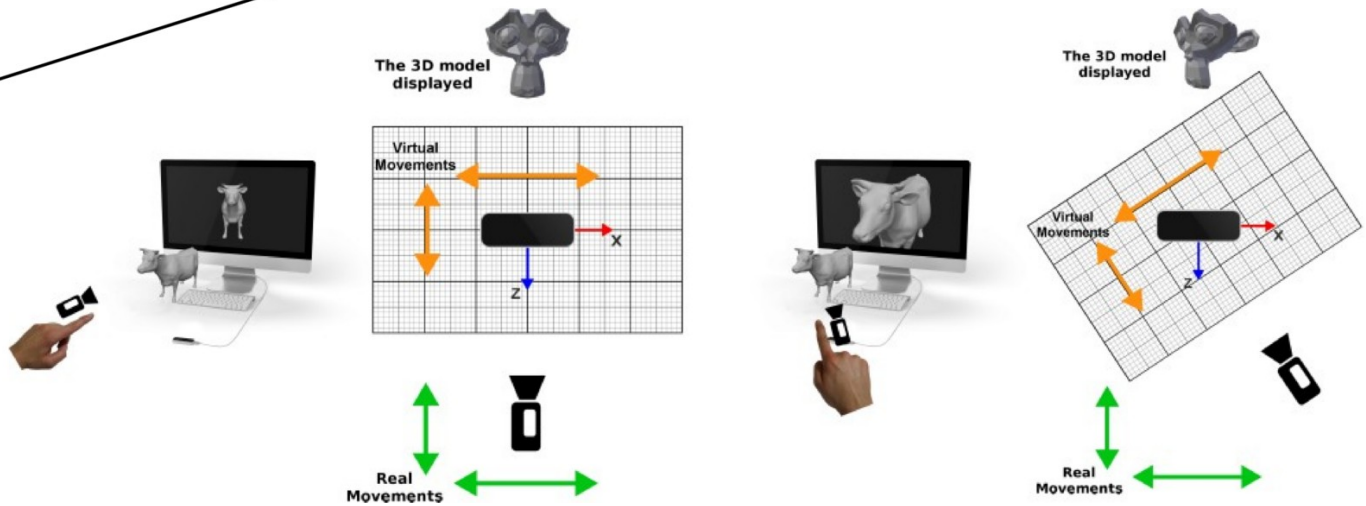
3D modelling environment



Environment

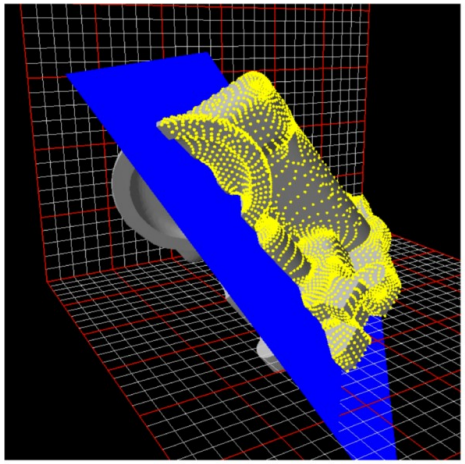


Objects

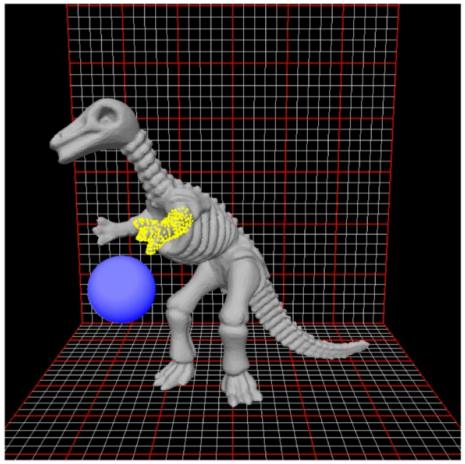


Camera

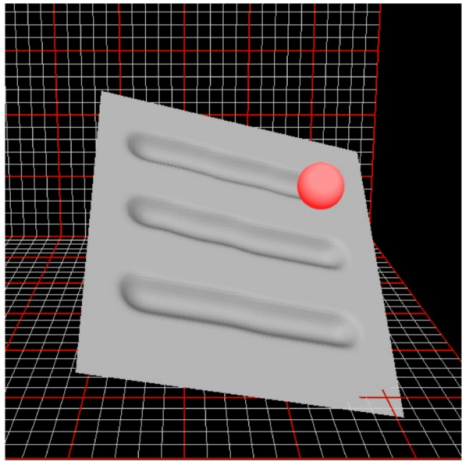
Modelling operations



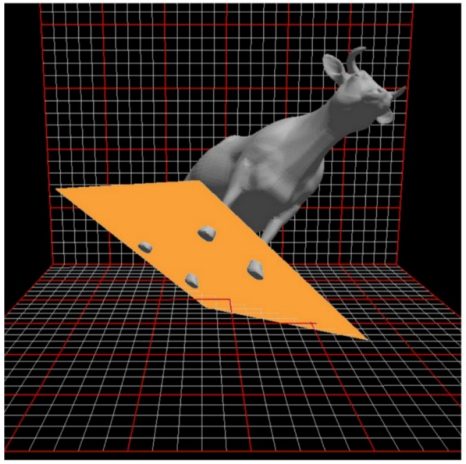
selection by plane



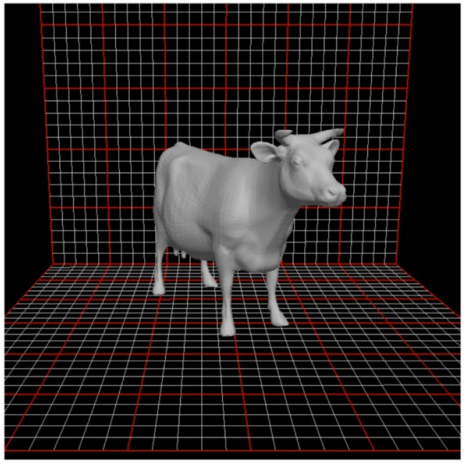
selection by sphere

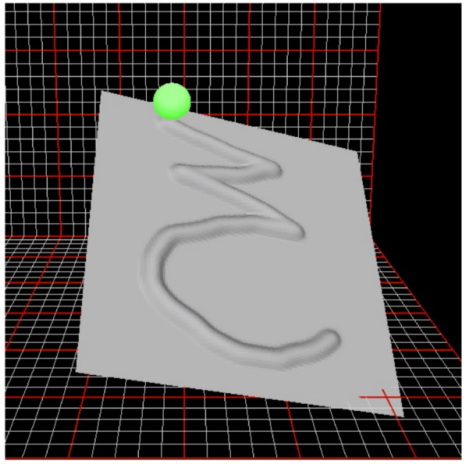


sculpture



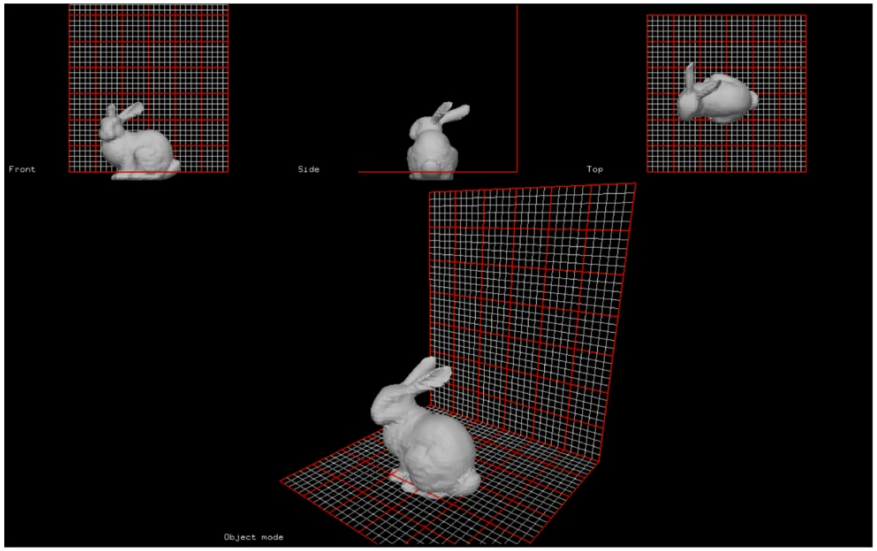
alignment

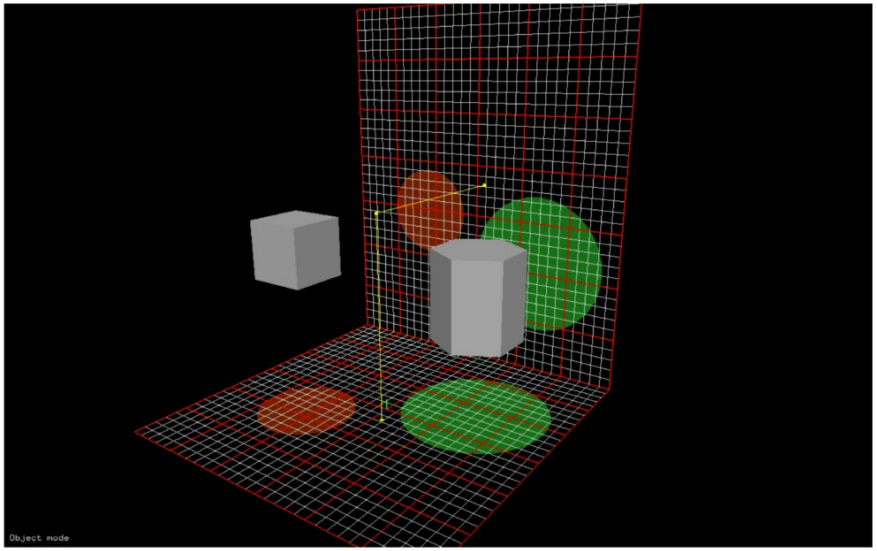


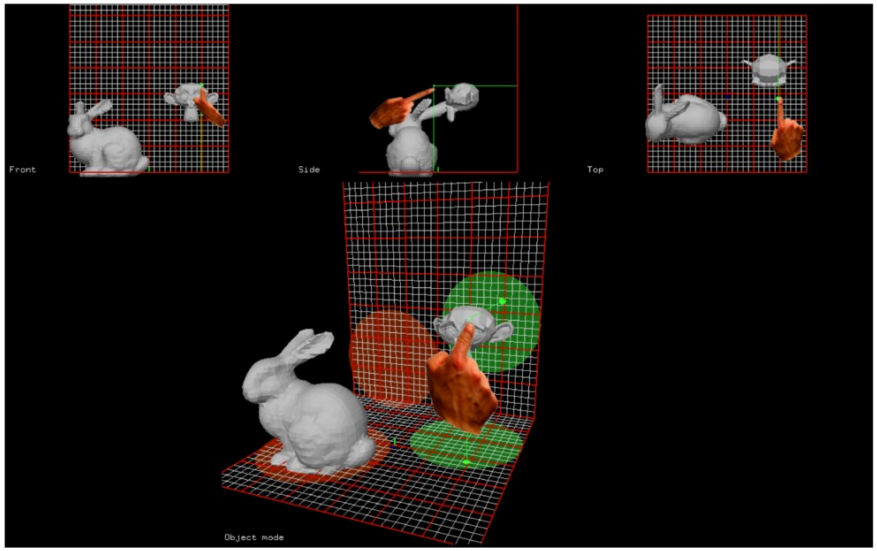


extrusion

The visualization solution







DEMO

Thank you for your attention! Questions are welcome.

Flavio Bertini
flavio.bertini2@unibo.it

Department of Computer Science
and Engineering