12th Summer School on SCIENTIFIC VISUALIZATION

Introduction to scientific Visualization

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CINECA

OUTLINE

- Definition
- Why visualization
- Pioneers
- What is not scientific visualization
- What is scientific visualization
- Examples
- Projects at CINECA
- Topics covered by the school

Definition

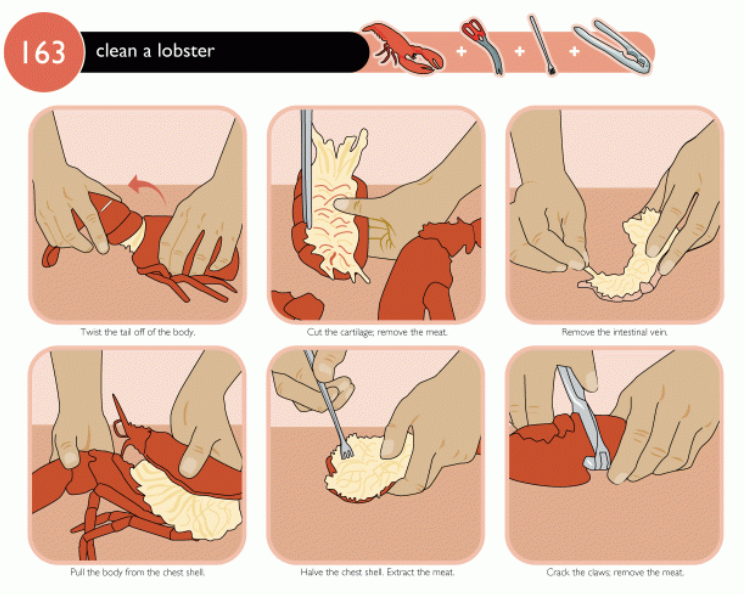
Scientific visualization (also spelled scientific visualisation) is an interdisciplinary branch of science according to Friendly (2008) "primarily concerned with the visualization of three-dimensional phenomena (architectural, meteorological, medical, biological, etc.), where the emphasis is on realistic renderings of volumes, surfaces, illumination sources, and so forth, perhaps with a dynamic (time) component".

It is also considered a branch of computer science that is a subset of computer graphics.

The purpose of scientific visualization is to graphically illustrate scientific data to enable scientists to understand, illustrate, and glean insight from their data.

[wikipedia, scientific visualization]

Why visualization



http://www.showmenow.com/

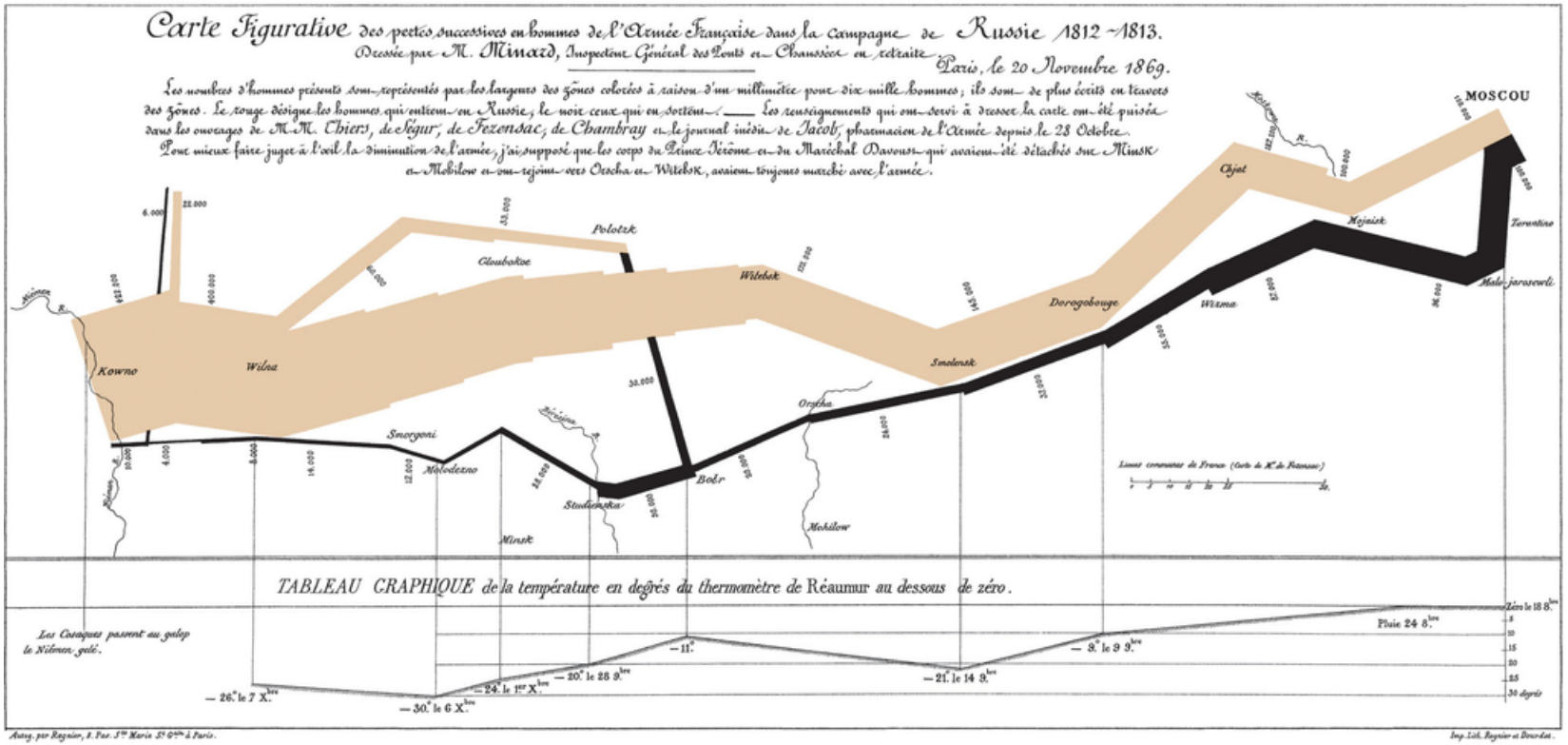
[..] His philosophy on scientific computing appears as preface to his 1962 book on numerical methods:

The purpose of computing is insight, not numbers

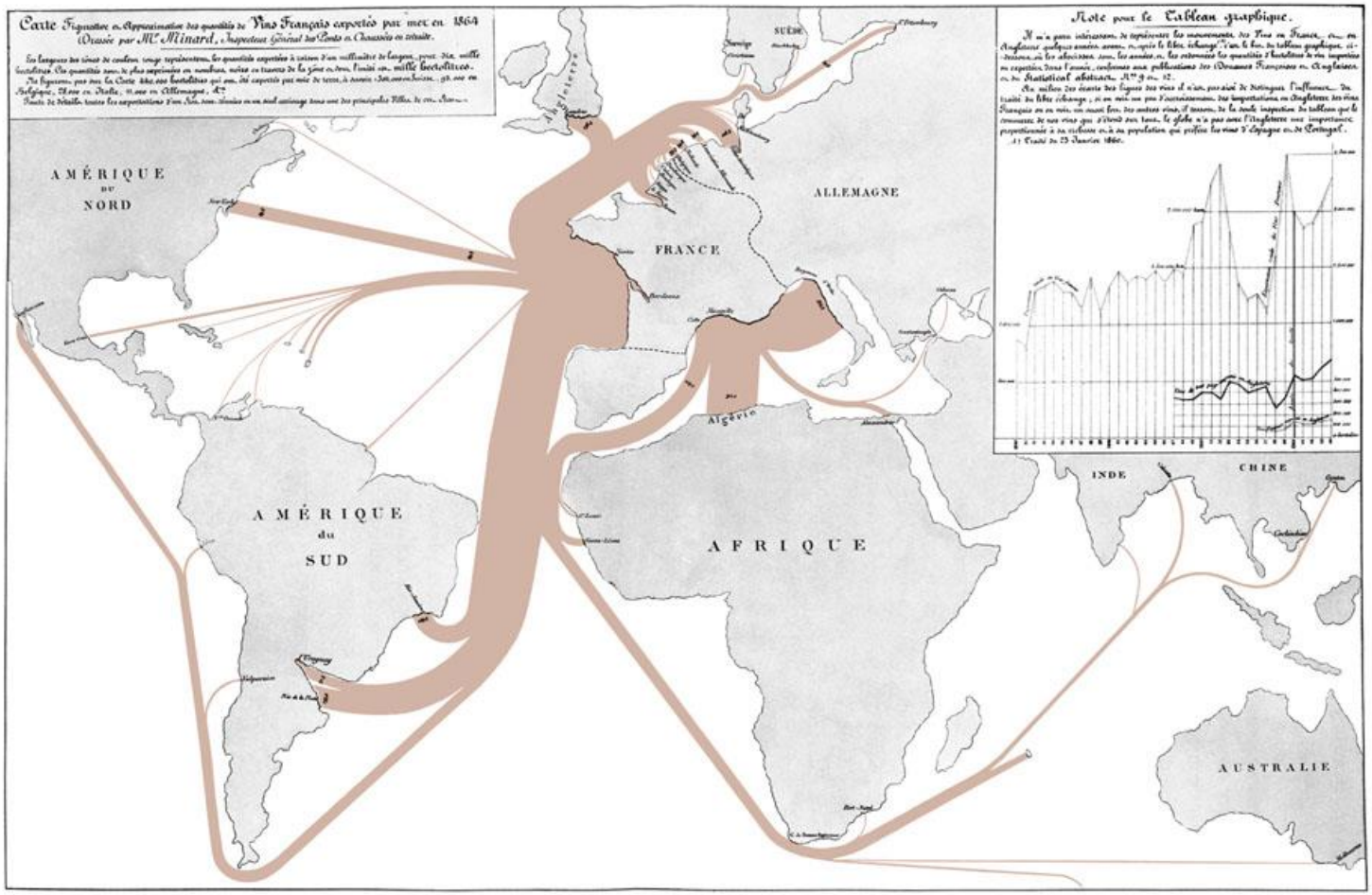
[…]

[wikipedia, R. Hamming]

Pioneers


Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.
Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite
Paris, le 20 Novembre 1869.
MOSCOU
Kowno
Wilna
Glubokoe
Polotzk
Witebsk
Smolensk
Dorogobouge
Wixma
Chjat
Mojaisk
Tarantino
Malo-jaroswetz
Smorgoni
Molodexno
Studienska
Minsk
Bobr
Orscha
Mohilow
TABLEAU CRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.
Les Cosaques passent au galop le Niémen gelé.
— 26.° le 7 X.bre
— 30.° le 6 X.bre
— 24.° le 1er X.bre
— 20.° le 28 9.bre
— 11.°
— 21.° le 14 9.bre
— 8.° le 9 9.bre
Pluie 24 8.bre
Zéro le 18 8.bre
30 degrés

Pioneers



Charles Joseph Minard, *Tableaux Graphiques et Cartes Figuratives de M. Minard*, 1845-1869, a portfolio of his work held by the Bibliothèque de l'École Nationale des Ponts et Chaussées, Paris.

Pioneers

http://marchingcubes.org

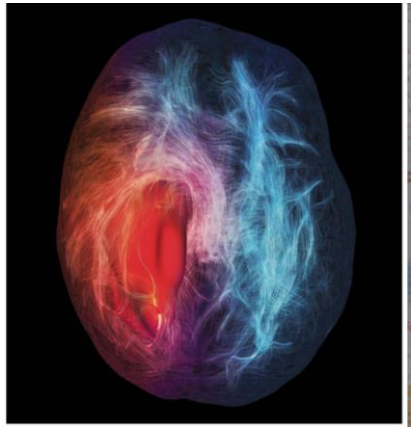
Bill Lorensen and Dick Bair (both at Watervliet Arsenal) looking at a Lundy Electronics vector refresh graphics display system. The graphics shows the results of a finite element nodal analysis.

Pioneers

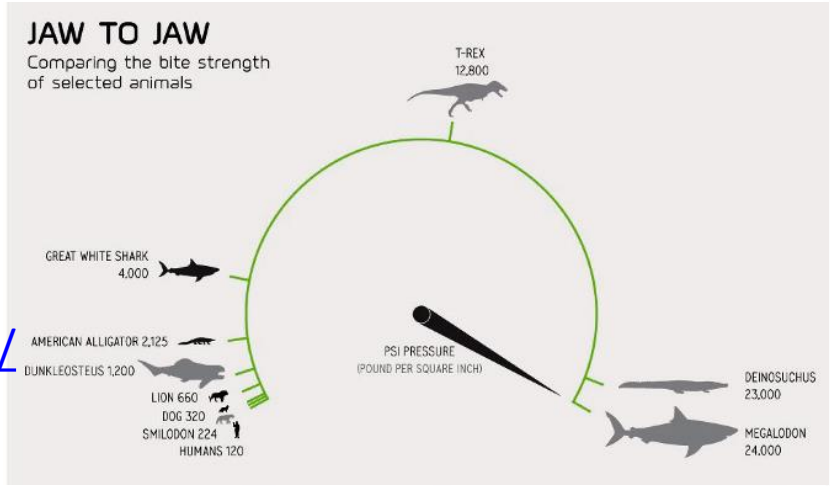
marchingcubes.org:
Shane Chang, Joyce Langan, **Will Schroeder, Bill Lorensen, Ken Martin,** Margaret Kelliher, October 20, 1994

WHAT IS NOT SCIENTIFIC VISUALIZATION (in this school)

http://vimeo.com/28776928

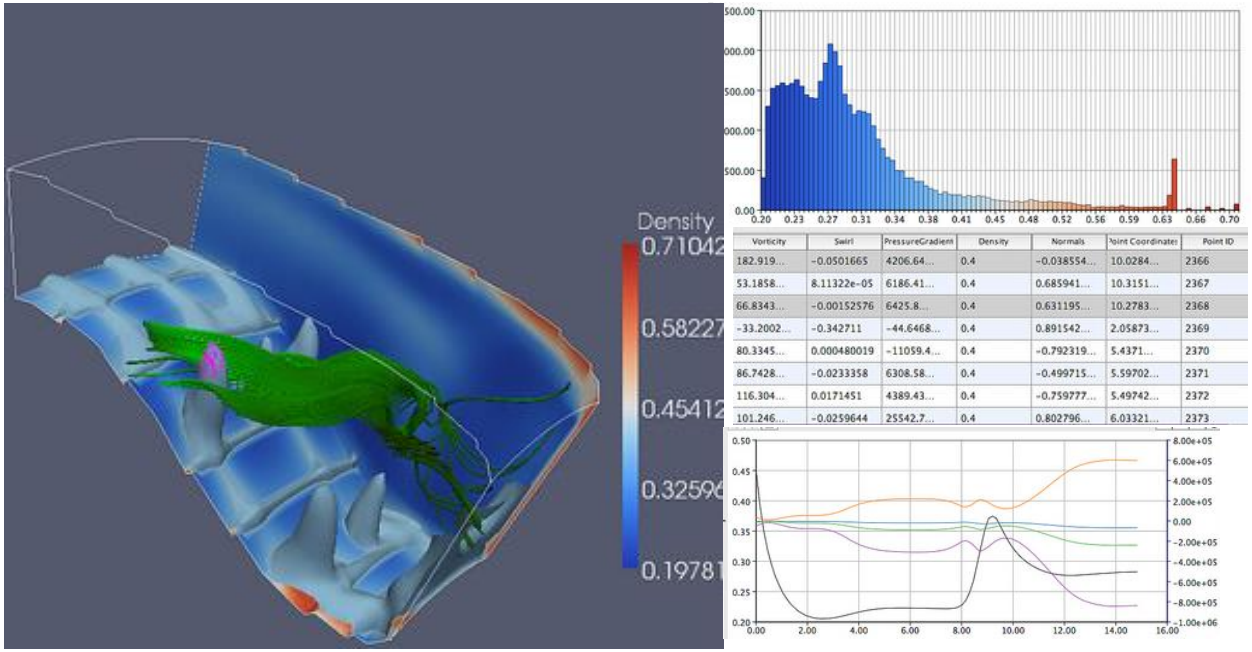


http://www.sciencemag.org/site/special/vis2012/



http://www.smithsonianmag.com/multimedia/videos/Jaw-to-Jaw.html

WHAT IS SCIENTIFIC VISUALIZATION (in this school)



Vorticity	Swirl	PressureGradient	Density	Normals	Point Coordinates	Point ID
182.919...	-0.0501665	4206.64...	0.4	-0.038554...	10.0284...	2366
53.1858...	8.11322e-05	6186.41...	0.4	0.685941...	10.3151...	2367
66.8343...	-0.00152576	6425.8...	0.4	0.631195...	10.2783...	2368
-33.2002...	-0.342711	-44.6468...	0.4	0.891542...	2.05873...	2369
80.3345...	0.000480019	-11059.4...	0.4	-0.792319...	5.4371...	2370
86.7428...	-0.0233358	6308.58...	0.4	-0.499715...	5.59702...	2371
116.304...	0.0171451	4389.43...	0.4	-0.759777...	5.49742...	2372
101.246...	-0.0259644	25542.7...	0.4	0.802796...	6.03321...	2373

http://www.ansys.com/Hall+of+Fame

EXAMPLES

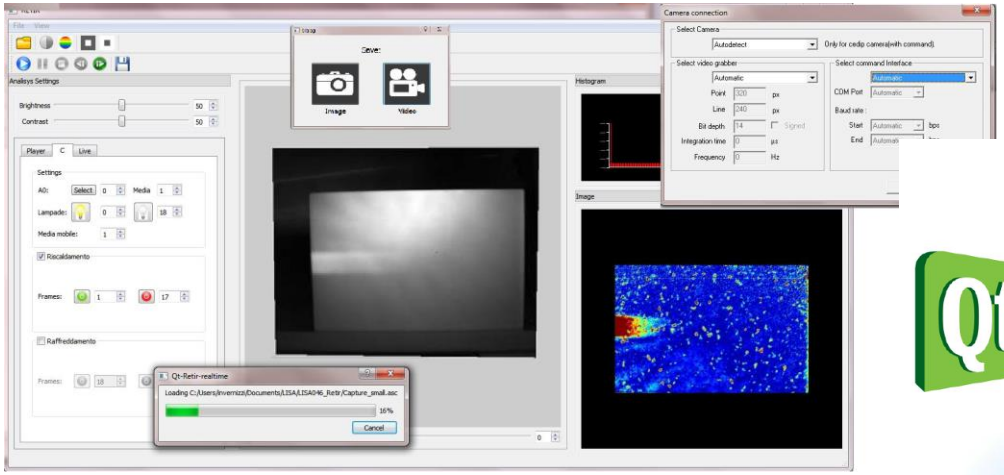
- http://www.kitware.com/solutions/scientificcomputing/scientificcomputing.html

Small visualization projects at CINECA

- RETIR: real time IR thermography non destructive testing

PI: A. Salerno, Politecnico di Milano

Developed by: Alice Invernizzi & Stefano Cotini at CINECA within a LISA grant.

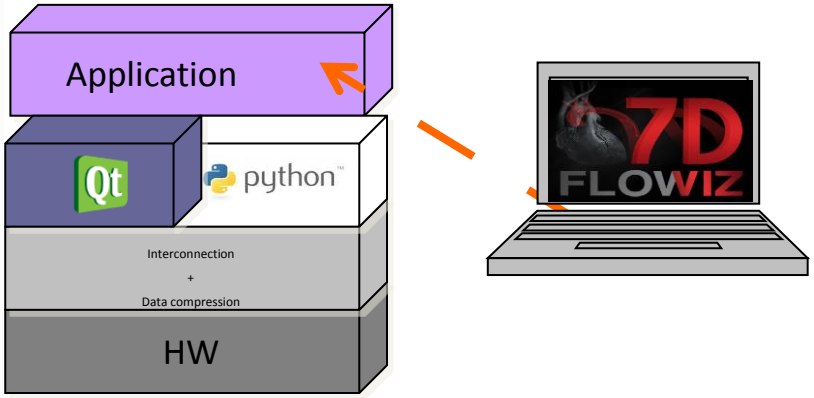


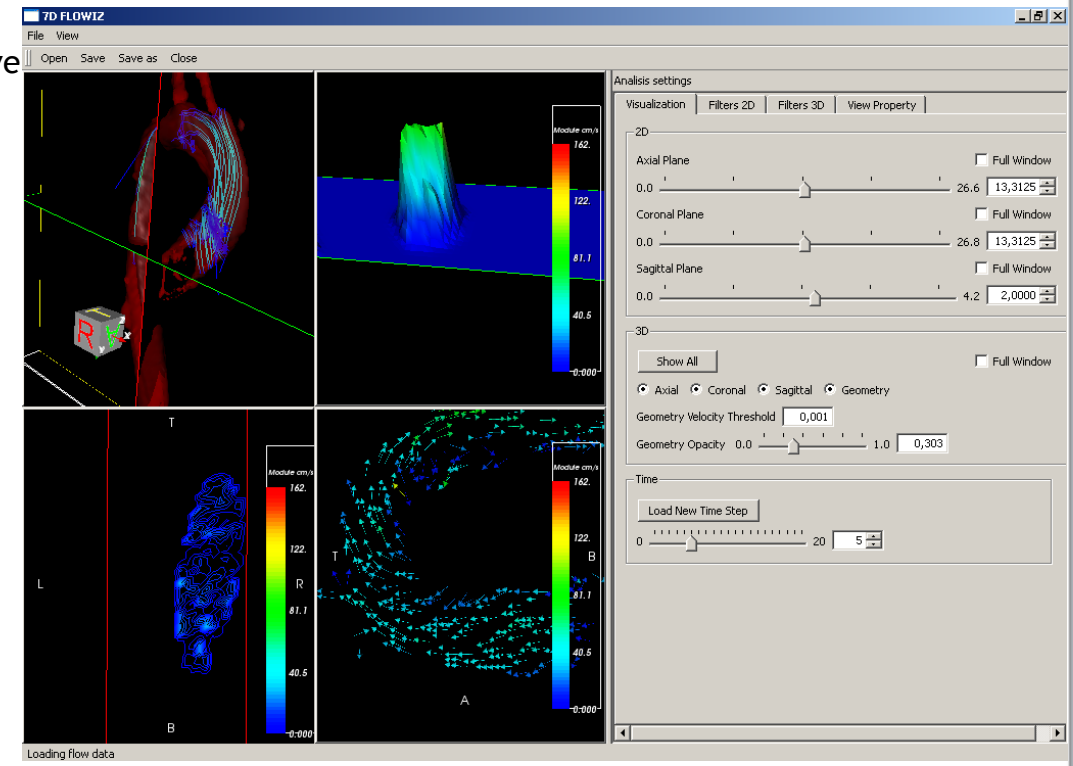
- Tools: Qt,C++,VTK,…

Small visualization projects at CINECA

- **FlowViz7d: A novel Python-based GUI application for in vivo hemodynamics visualization and computing**

Presented at the EUROSCIPY 2012 by :
Raffaele Ponzini, CINECA, Segrate (MI), Italy
Alice Invernizzi, CINECA, Segrate (MI), Italy
Francesco Iannaccone, biommeda, Ibitech , Ghent Unive
Giovanna Rizzo, IBFM-CNR, Milan, Italy



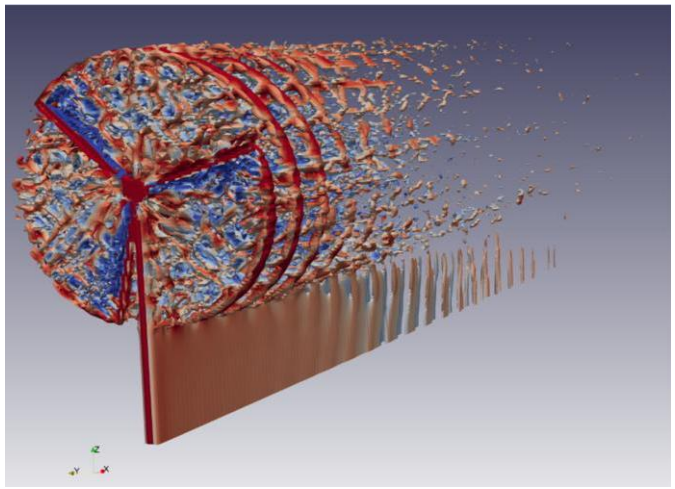


- Tools: Python,Qt,VTK

In situ visualization using Paraview+Python

PRACE 5thCALL: INCOME4WINDFARMS - Innovative Computational Methods for Wind Farms

- **Project leader**: Paolo Schito, Politecnico di Milano, Italy
- **Collaborators**: Raffaele Ponzini, CINECA, Italy | Alice Invernizzi, CINECA, Italy | Alberto Zasso, Politecnico di Milano, Italy | Catherine Gorlé, Stanford University, United States
- Tools: Python,Paraview,OpenFoam



MAF Applications

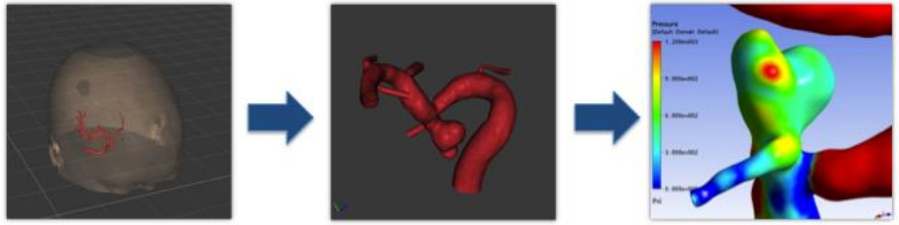
Some visualization applications from SCS developed with the MAF framework

AIMA – Aneufuse	(MAF v.2)
Carditis	(MAF v.1)
HipOp	(MAF v.2)
HyperMonitor	(MAF v.3)
iPose	(MAF v.2)
LHPBuilder – PSLoader	(MAF v.2)
MSV-Application	(MAF v.3)
NMSBuilder	(MAF v.2)
Odous	(MAF v.2)
Vpalp	(MAF v.2)
VPH2	(MAF v.2)

AIMA

- **The RT3S** project is an international cooperative effort funded by the European Commission that developed and validated a sophisticated patient-specific, probabilistic model of the fatigue-fracture of a stent, integrated in a computer-aided surgery planning application, implemented to run in real-time during the surgical planning, so as to provide advice of the risk of stent rupture while the surgeon is planning the operation.
- **AIMA** is the vertical application based on **MAF2**

AIMA*beta*
Vascular Modelling



BioComputingCompetenceCentre

Disclaimer:
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rt 3S
Real Time Simulation for Safer vascular Stenting

Carditis

Carditis is a software for the visualisation and fusion of cardiological data.

Features:

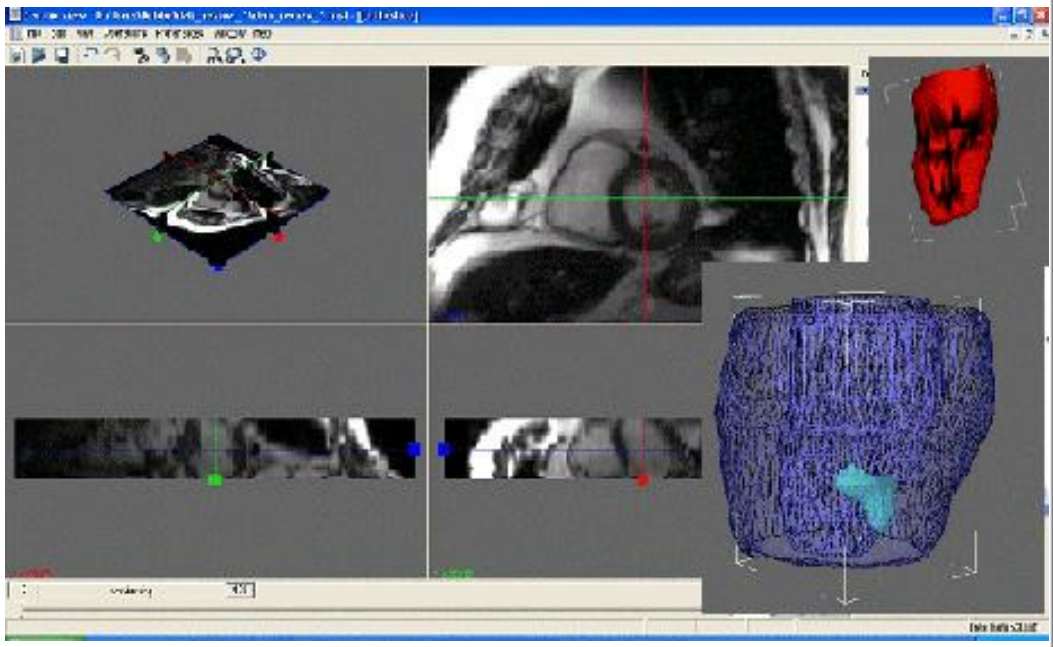
•import medical images using the standard DICOM format

•import CT, MRI (both static and dynamic) and X-ray data

•have an effective and interactive multimodal visualisation

•have advanced functionalities for the registration and segmentation

•Save any visualisation as bitmap images.

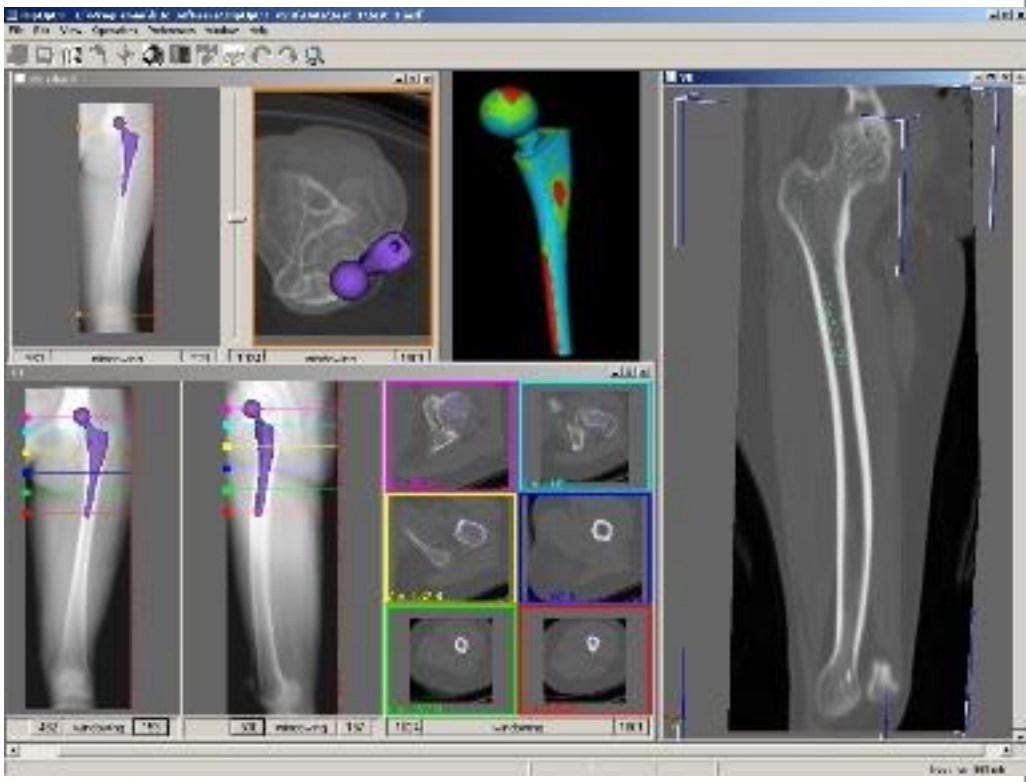


HipOp

HipOp is a software for the pre-operative planning of total hip replacement.

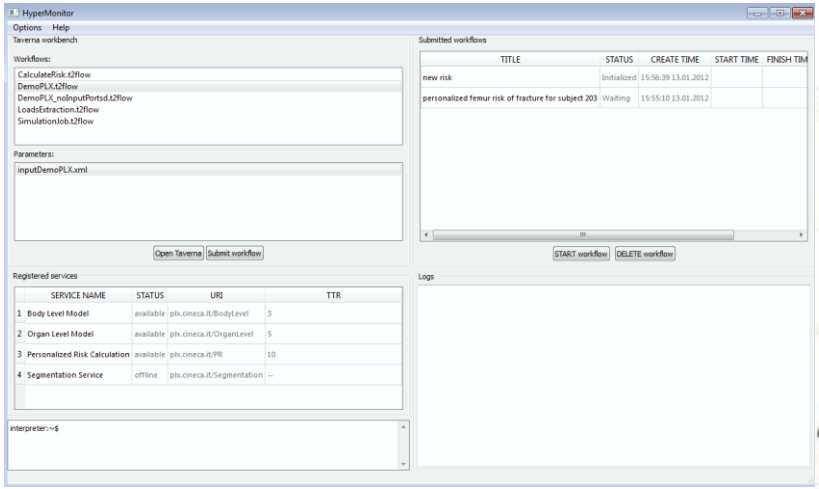
Features:

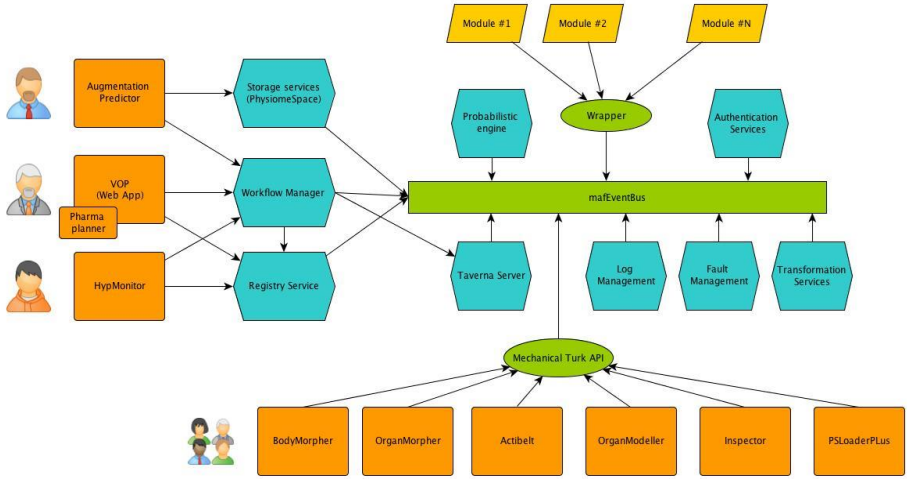
- Import your patient's DICOM data
- Visualise the patient's data with advanced visualisation techniques
- Use commercial prosthetic models for the planning
- Interactively position the prosthetic component into the patient's anatomy
- Save intermediate poses of the prosthesis
- Realise 2D measurements of desired features



Hypermonitor

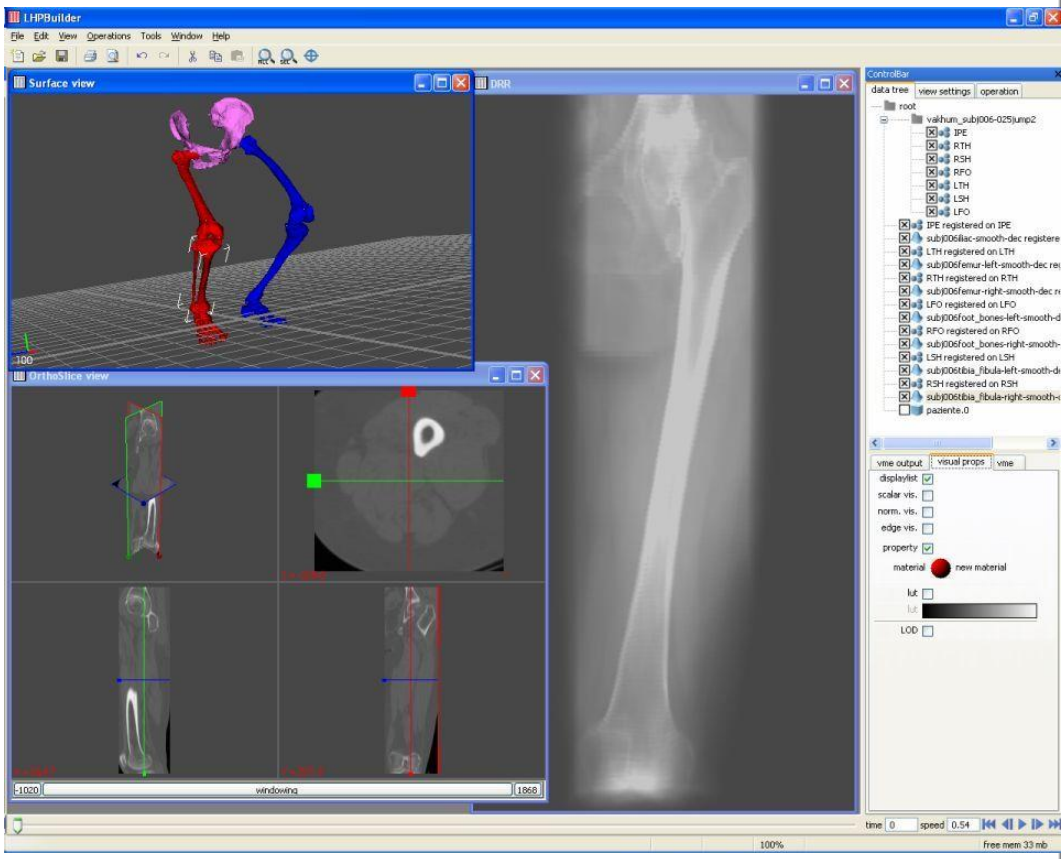
HyperMonitor is a desktop application based on **MAF3** for manage the workflow submission in the HyperModel technology, in VPHOP project.





LHPBuilder - PSLoader

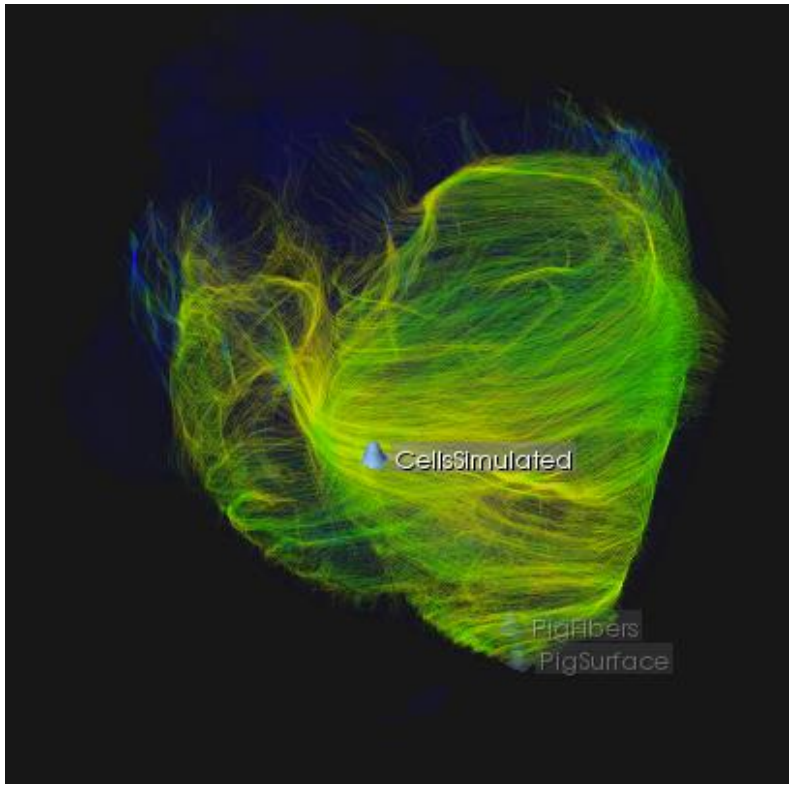
The **LHPBuilder** is an application developed using MAF2 a software tool to import, fuse, and store on the digital library almost any type of biomedical data, including medical images in DICOM format, gait analysis data, finite element analysis results, time-varying signals.



MSV-Application

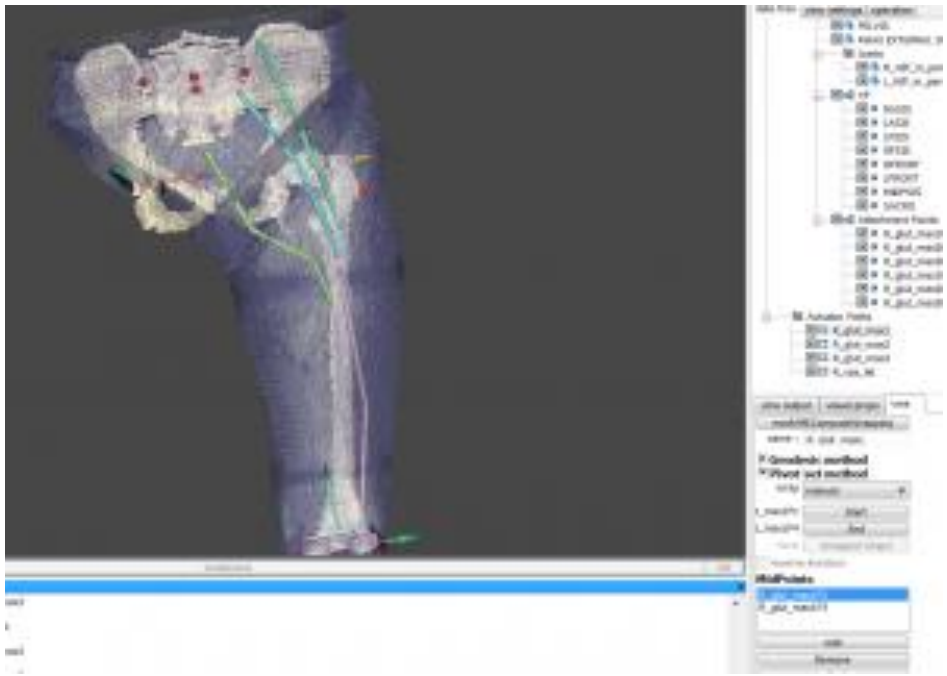
Multiscale Spatiotemporal Visualisation:

- Development of an Open-Source Software Library for the Interactive Visualisation of Multiscale Biomedical Data
- Create a **MAF3** Application which uses MSVTK library

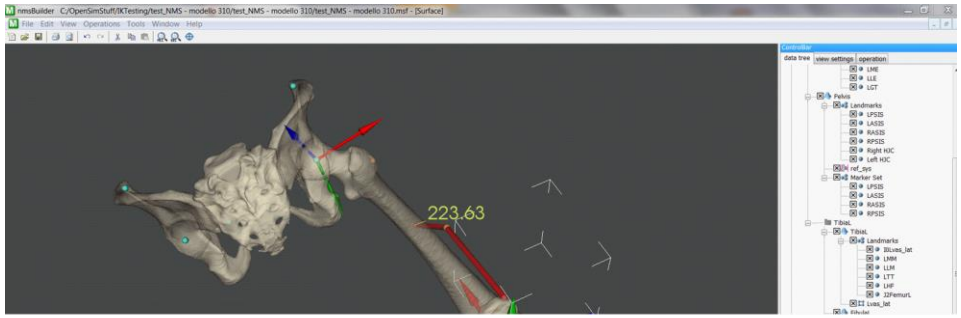


NMSBuilder

•NMS Physiome-SIMBIOS cooperation: Tools to develop the Neuro Musculo Skeletal Physiome

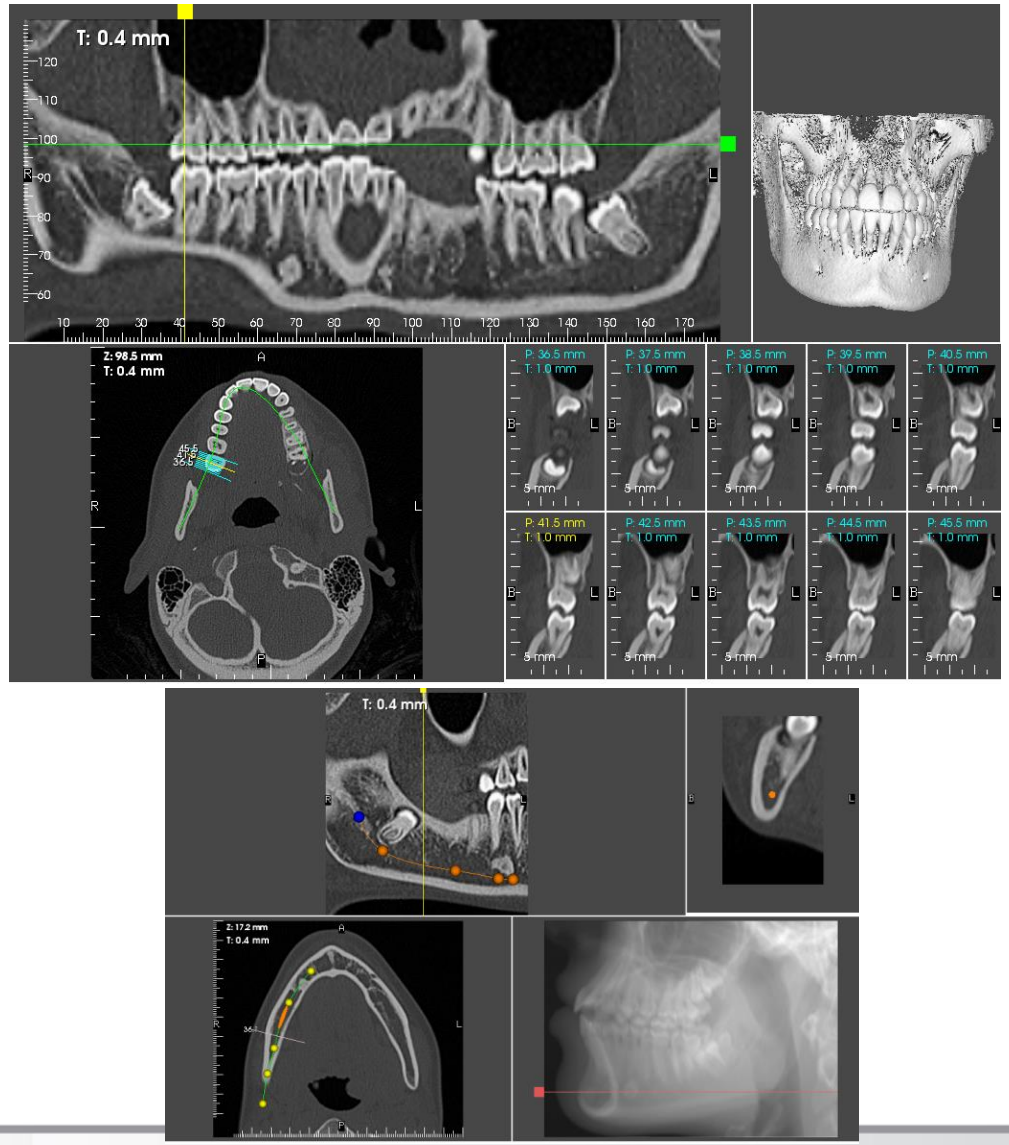


simbios VPHOP
NMS PHYSIOME
Personalised models of the neuromusculoskeletal system



Odous

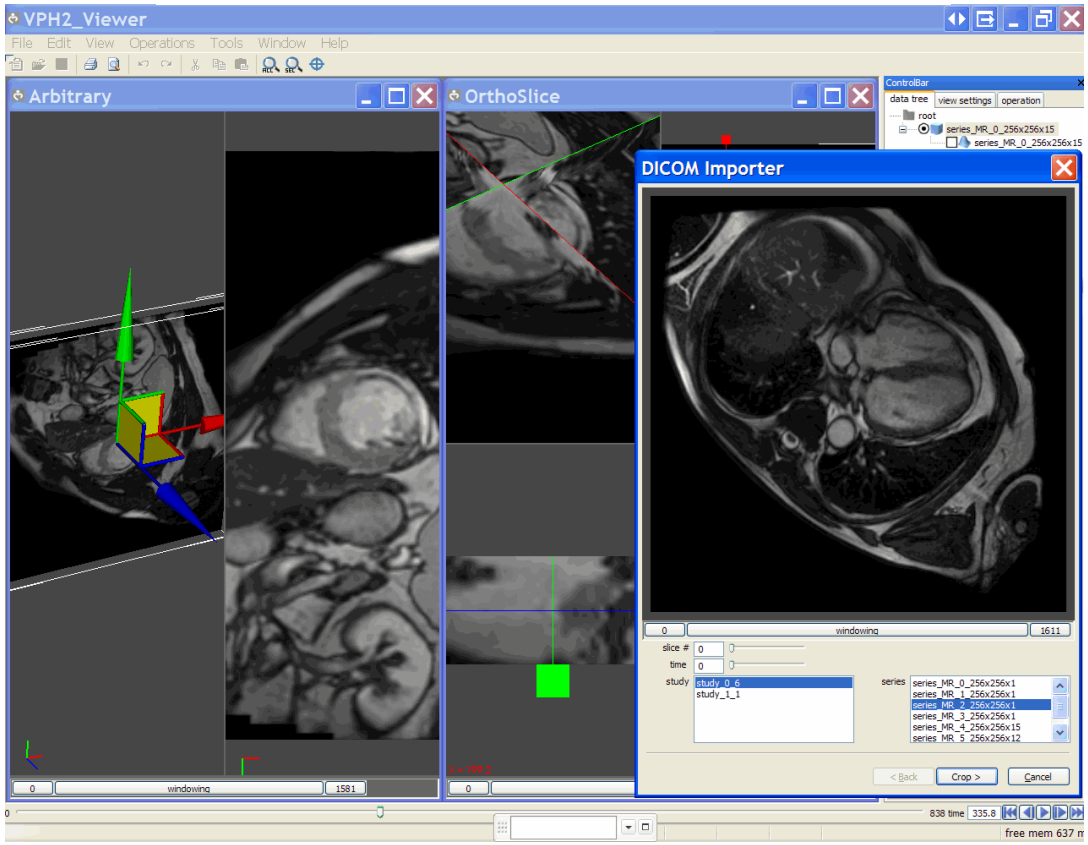
Odous is a software for 3D Dental Imaging that has been released in private beta version by B3C. The software offers state of art of visualization and helpful functionalities for advanced reporting. Through its fully 3D representation Odous is a powerful tool for implant planning, cephalometry but also it is an effective tool for clinician-to-patient communication.



VPH2

VPH2 VIRTUAL PATHOLOGICAL HEART

•**VPH2** aims to develop a patient-specific computational modelling and simulation of the human heart to assist the cardiologist and the cardiac surgeon in defining the severity and extent of disease in patient with Left Ventricular Dysfunction (LVD) , with or without Functional Mitral Regurgitation (FMR).



DECLARED INTENTIONS

Open-source
Cross-platform
Well documented
Python based

TOPICS COVERED BY THE SCHOOL

Day	Topics
Monday 10	Python for scientific visualization
Tuesday 11	VTK
Wednesday 12	Paraview
Thursday 13	Qt; Remote Rendering
Friday 14	Scientific Visualization in bio-CFD and External Aerodynamics CFD applications

Basic plotting concepts and tools using Python programming Language

Introduction to a state-of-the-art scientific visualization library

Introduction to a state-of-the-art scientific visualization application with GUI

Introduction to a state-of-the-art library to build GUI (Qt) using the Python programming Language; Remote Rendering services at CINECA

Case history on specific real-life applications:

- bio-CFD
- external aerodynamics