1er Colloque annuel ITMO Technologies pour la Santé

Paris

23 octobre 2009

Patient Specific Computer Assisted Surgery

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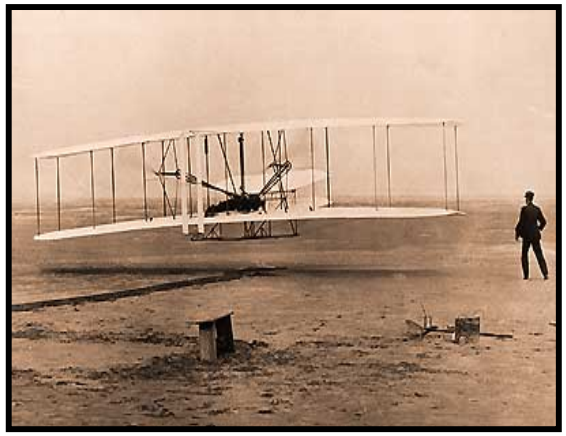
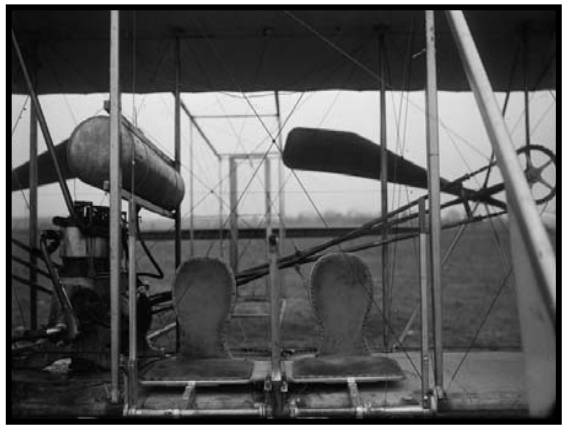
University of Strasbourg, France

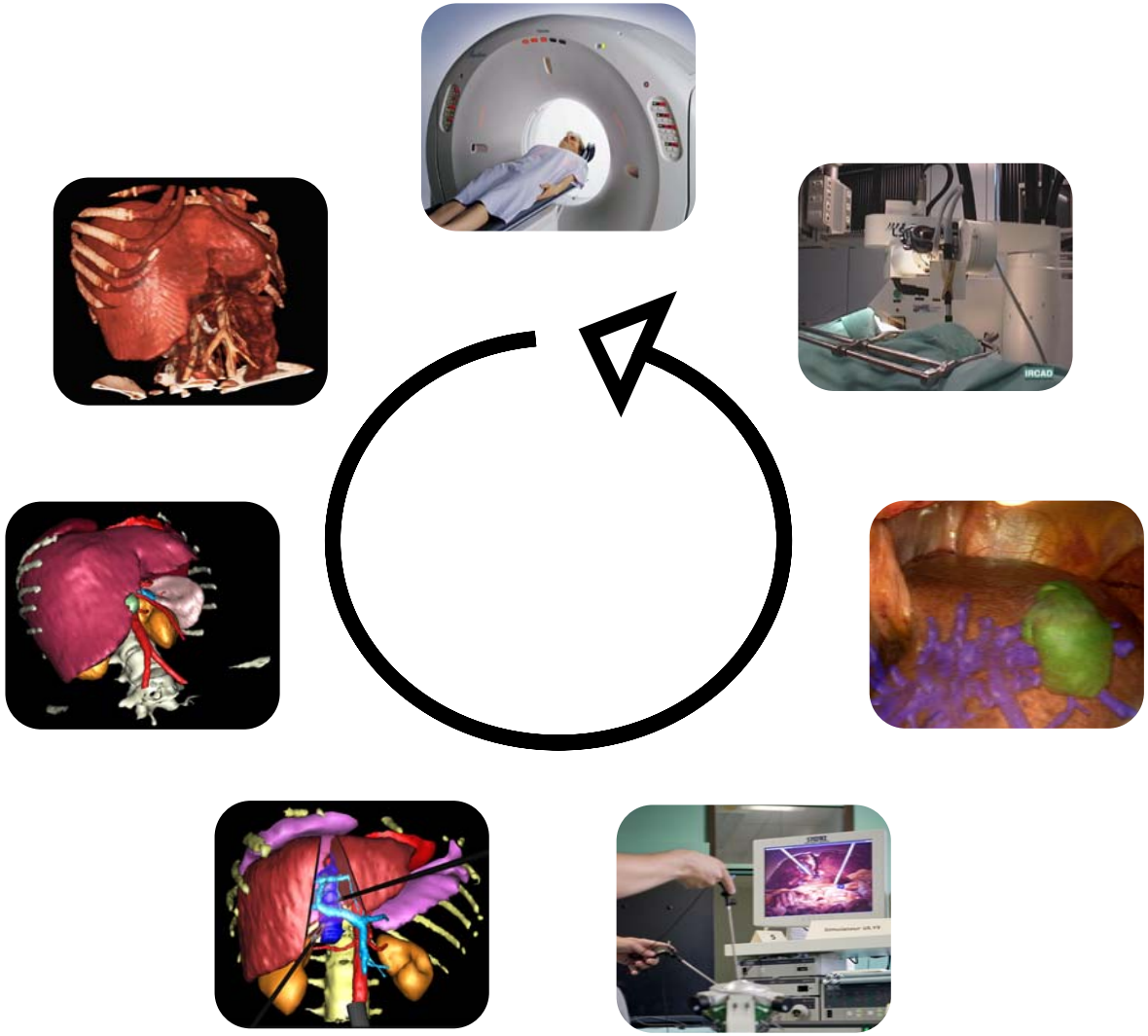
eats ircad eits

Future based onto known success

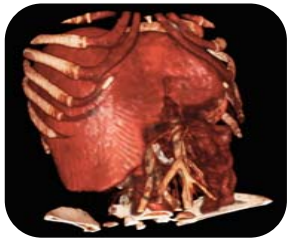




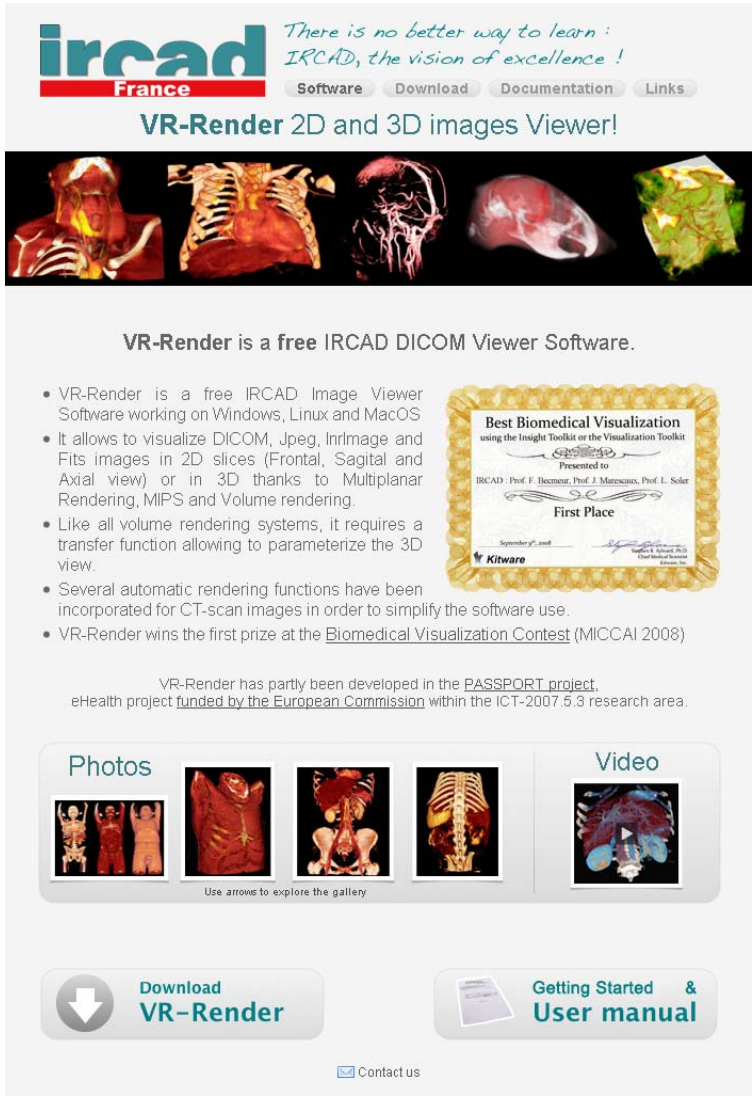
Computer Assisted Surgery



Step 1: 3D Direct Visualisation



VR-Render : Direct visualisation



FREE : www.ircad.org

➢20.000 downloads

Since october 2008

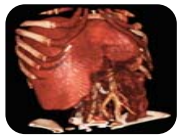
Mac OS / Windows/ Linux

2D/3D view of patient

Best Biomedical Visualisation Kitware Award

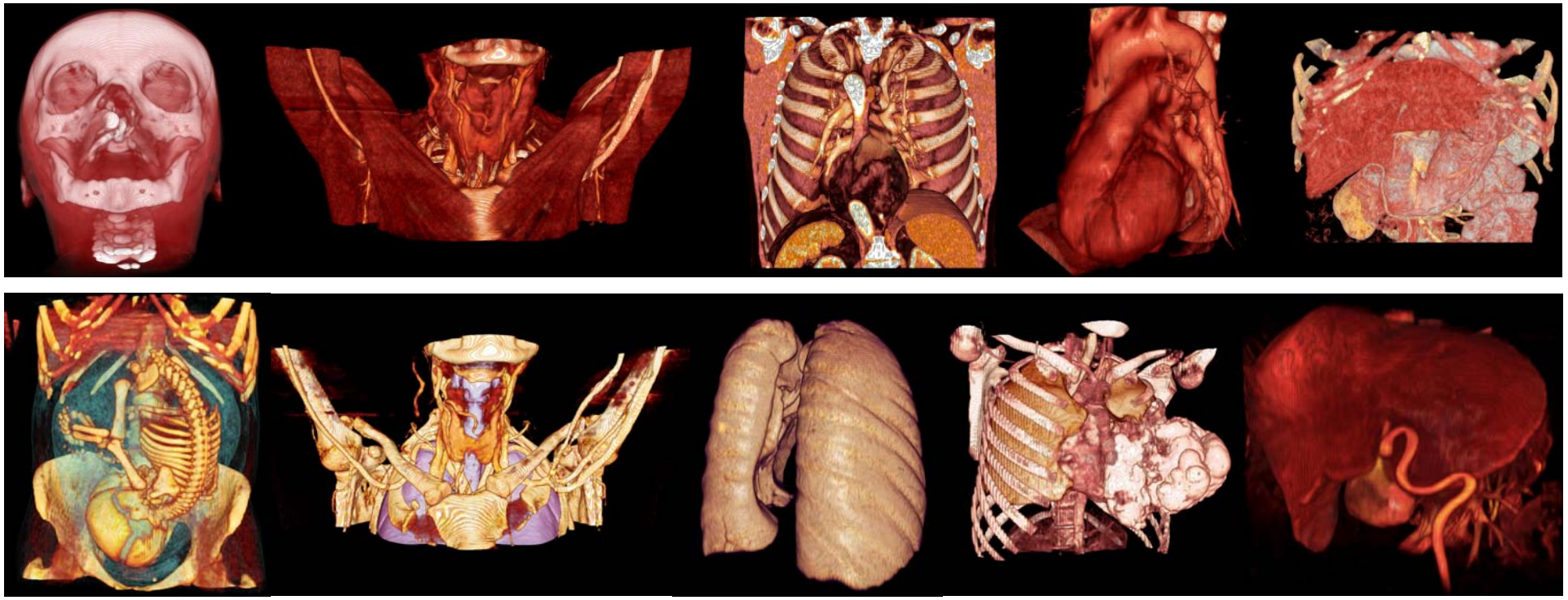
MICCAI 2008 : 1rst Prize

MICCAI 2009 : 1rst Prize

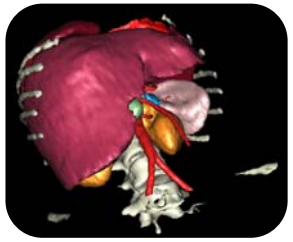


VR-Render : Direct visualisation

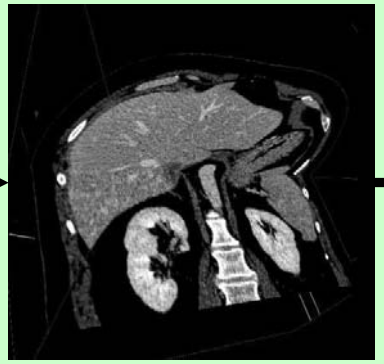
Sample of Direct Volume Rendering
VR-Render (freeware @IRCAD 2008)



Step 2 : 3D Patient Modelling



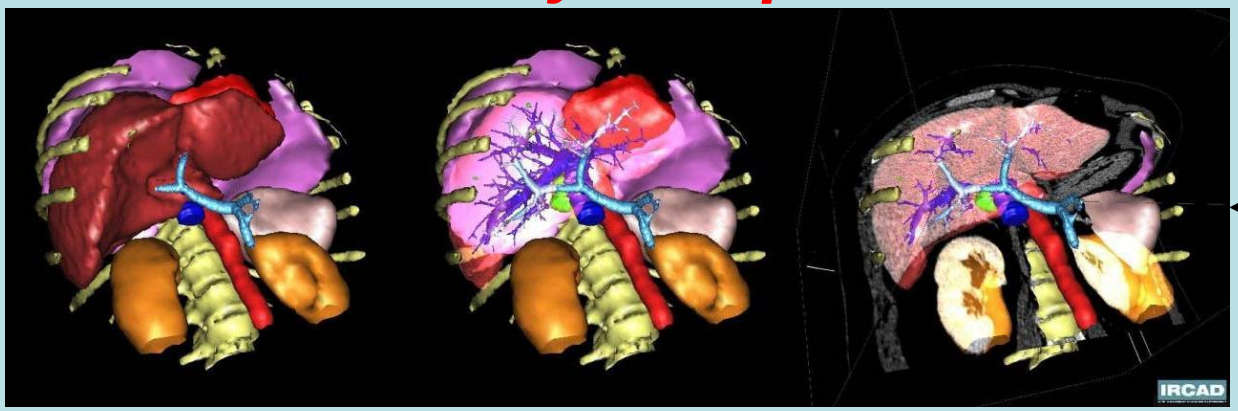
3D Modeling of Patients



Radiological department

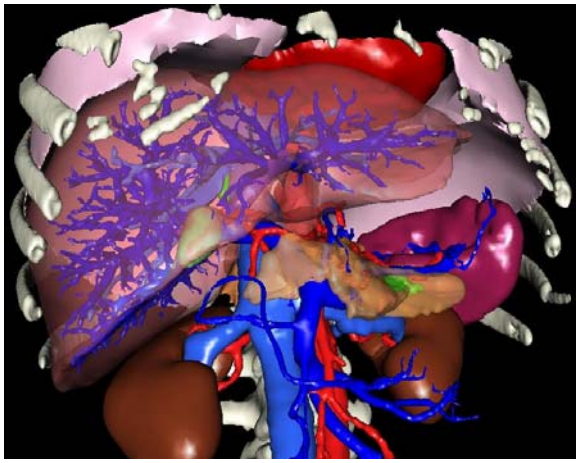
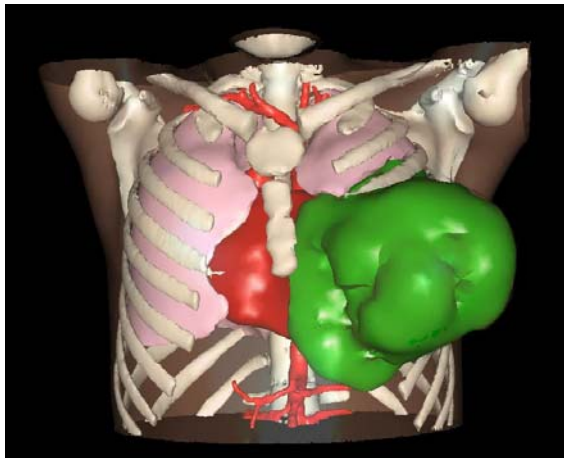
Online connection

3D/4D Analysis Department

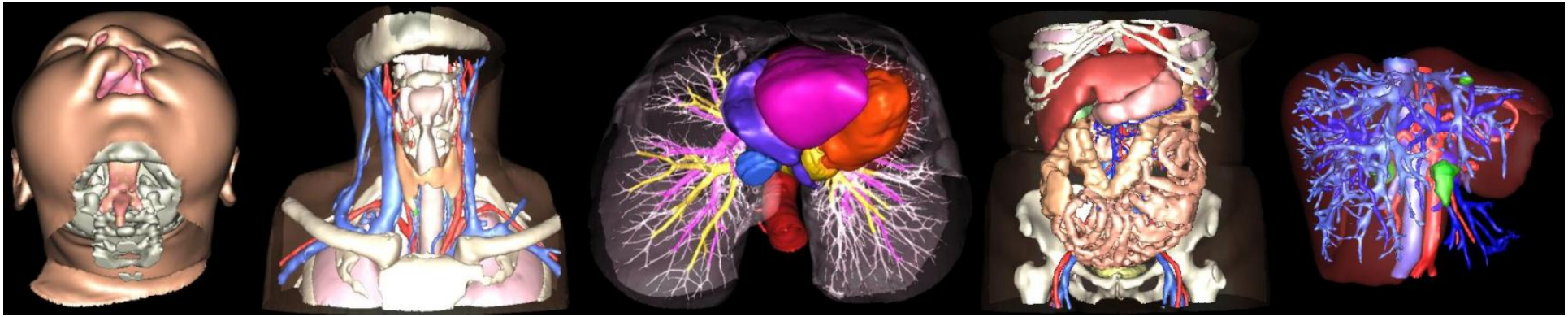


3D Modeling of Patients

IRCAD R&D online 3D Modeling service

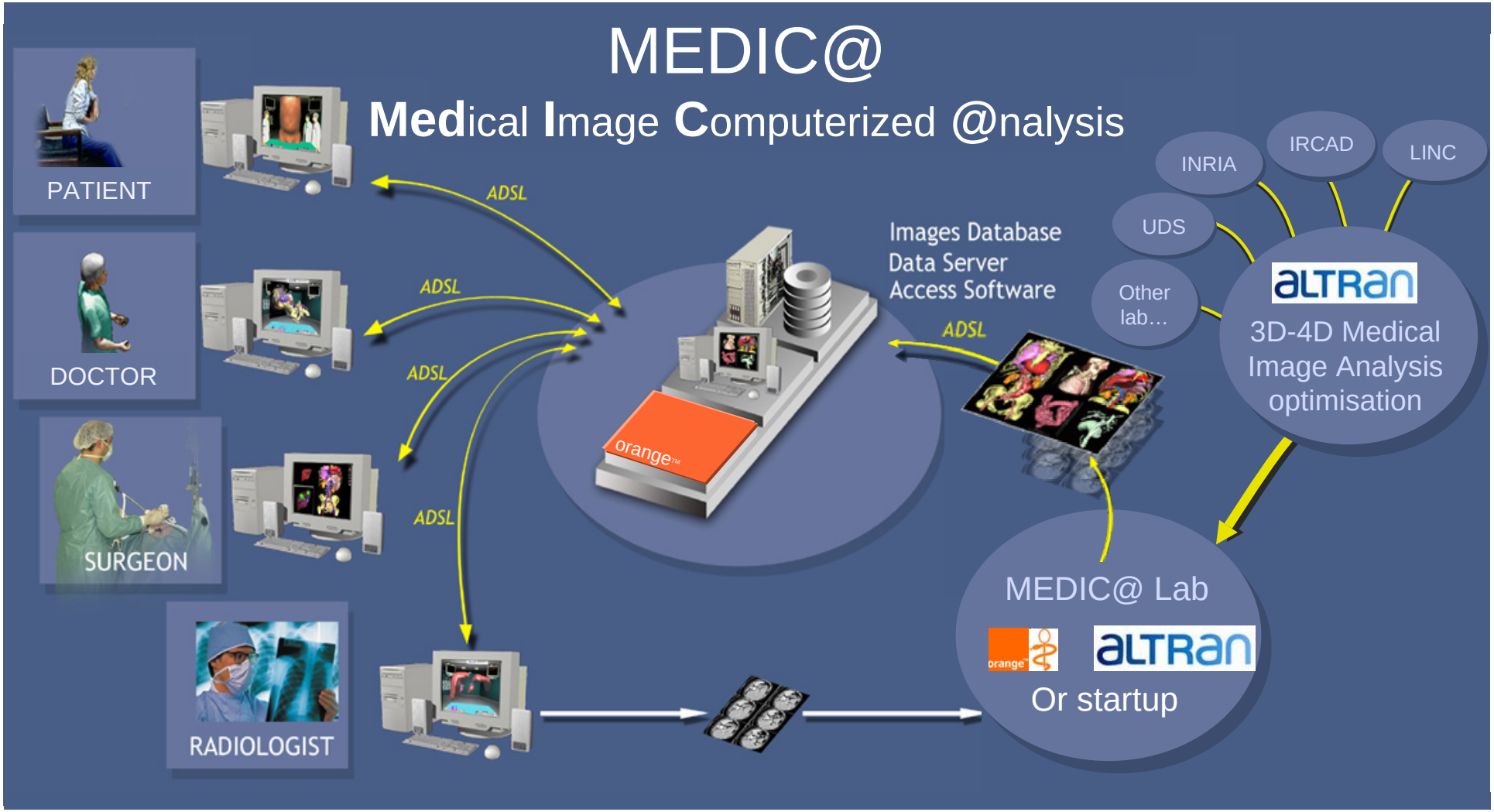




More than 500 patients from 5 CHU since 2006



Strasbourg, Montreal, Lausanne, Geneva, Bruxels Hospitals

A new Project : 2010 - 2012



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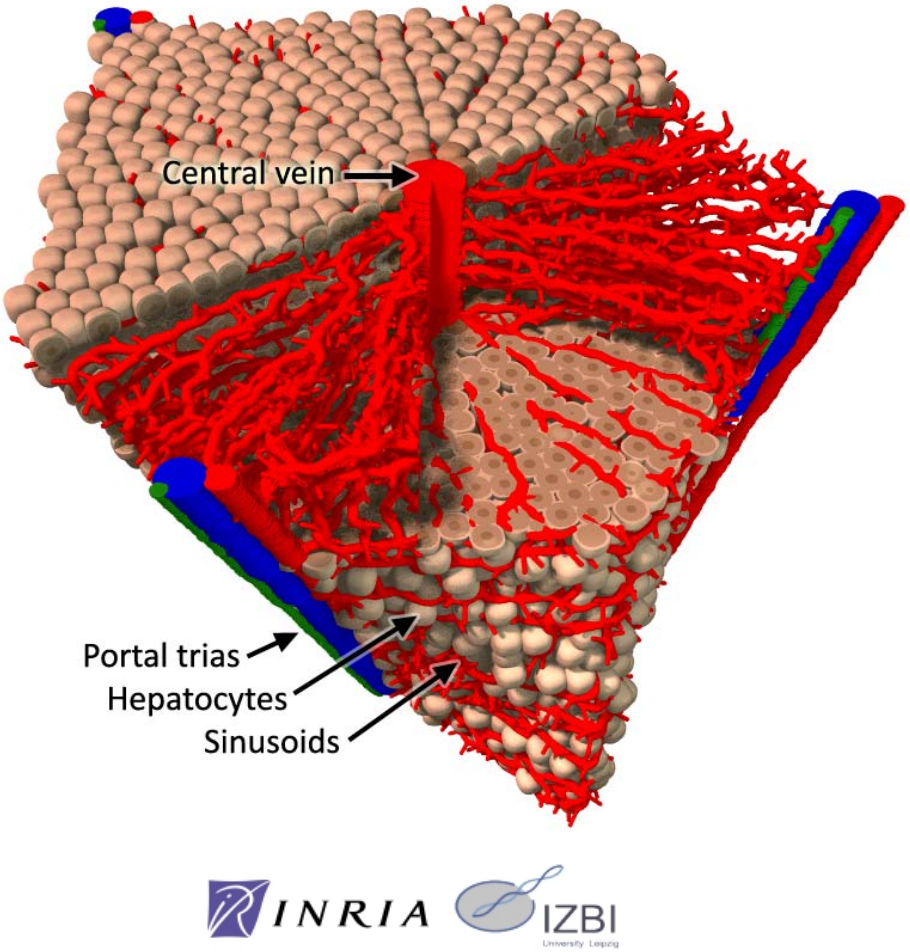
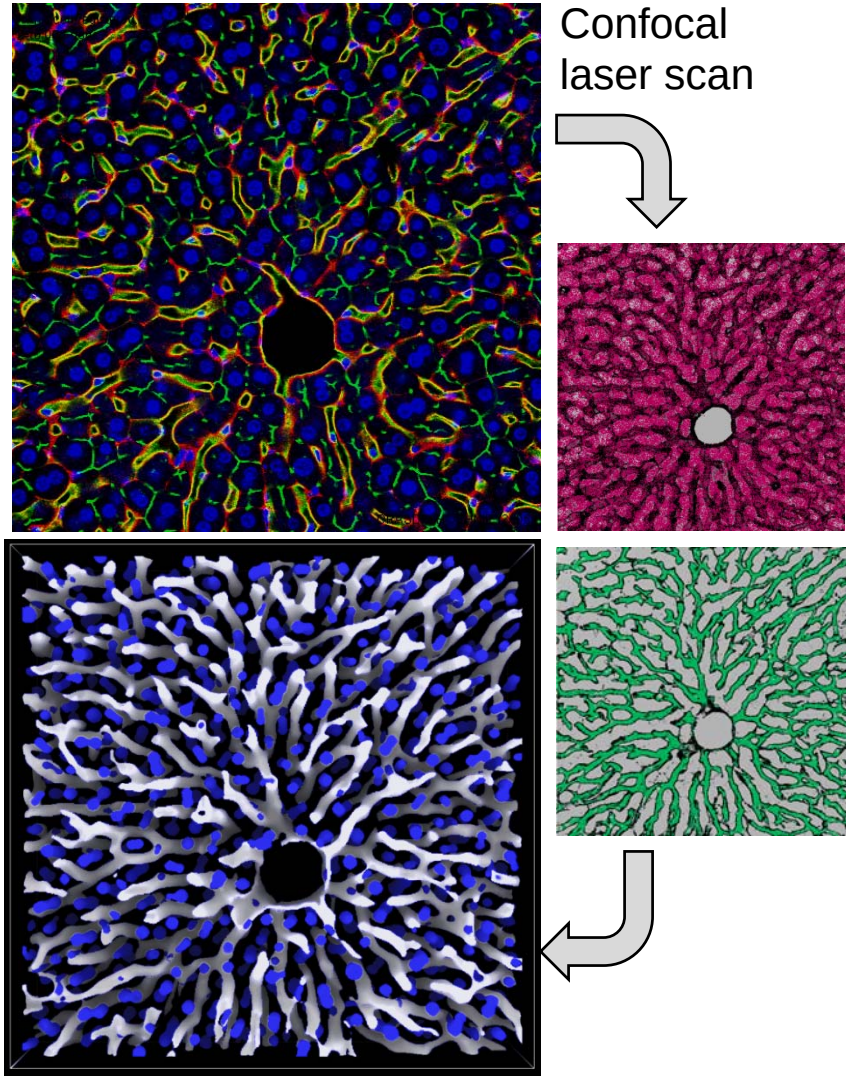
Lobule modelling

eHealth

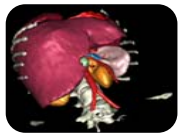
Lobule modelling



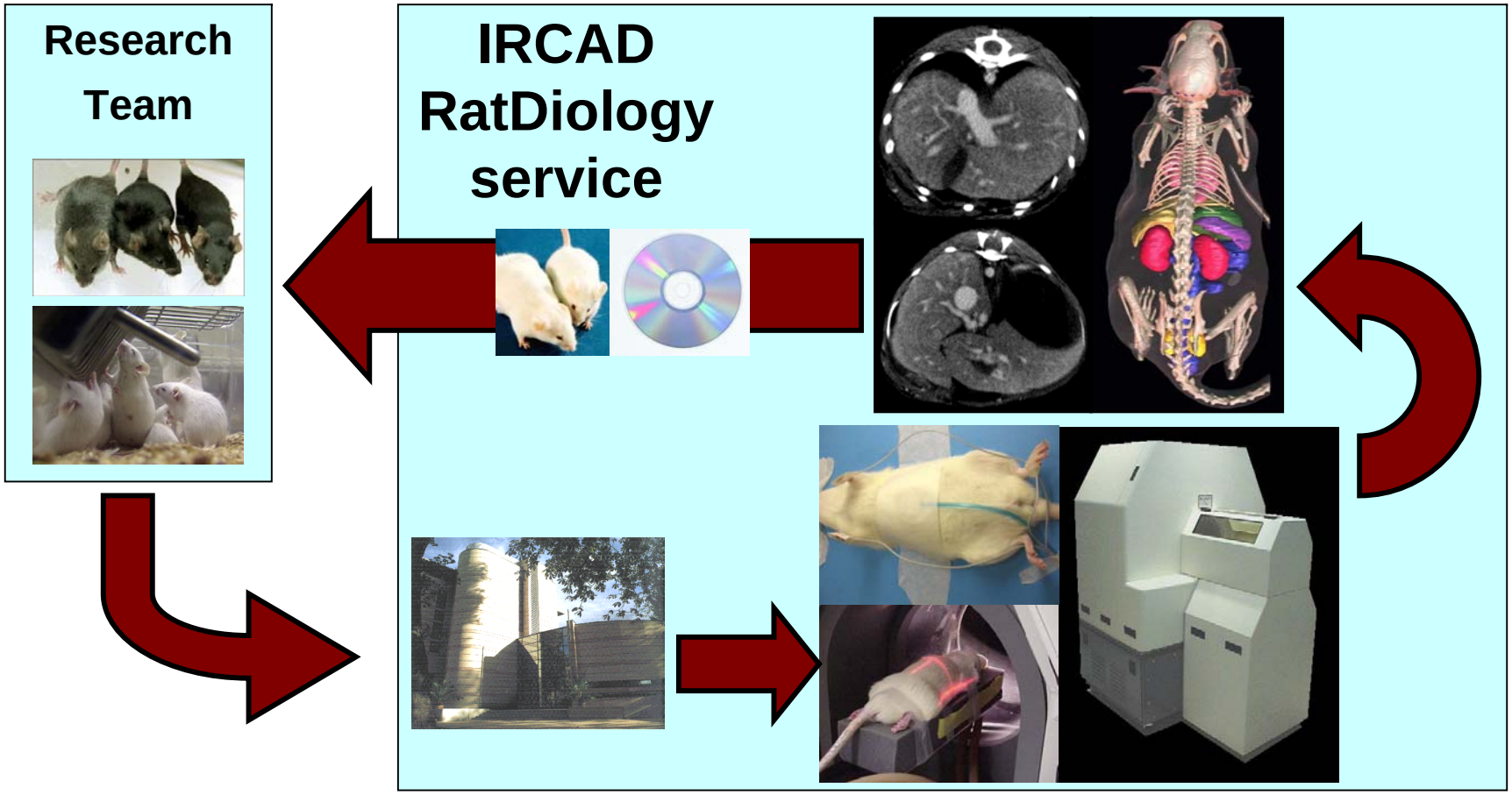
INRIA IZBI



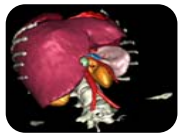
Dirk Drasdo, INRIA, IZBI



3D Modeling of Small Animals

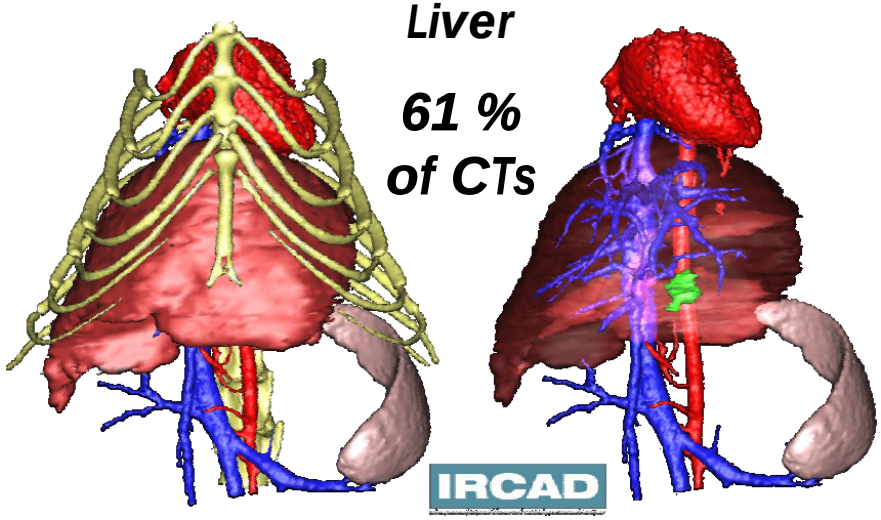


RatDiology Project



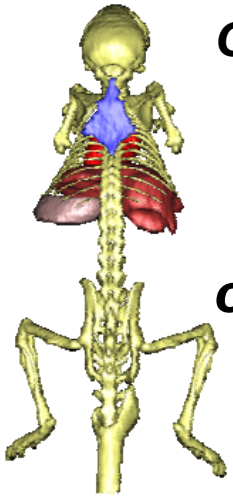
IRCAD RatDiology Service

Liver



61 % of CTs

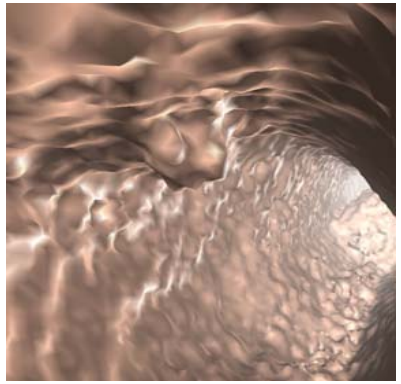
Other

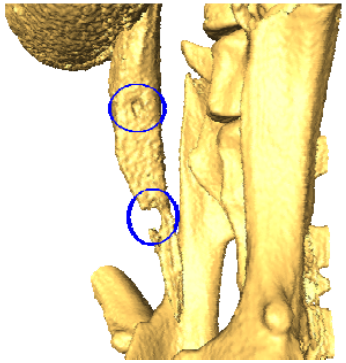


5% of CTs

More than 3000 CTs since 2005

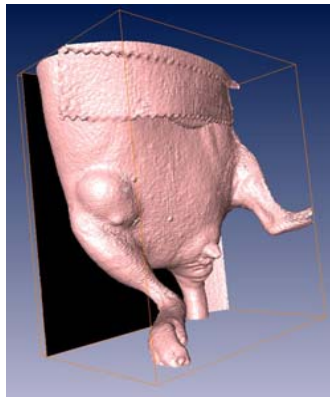
Colon





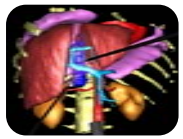
23% of CTs

Underskin

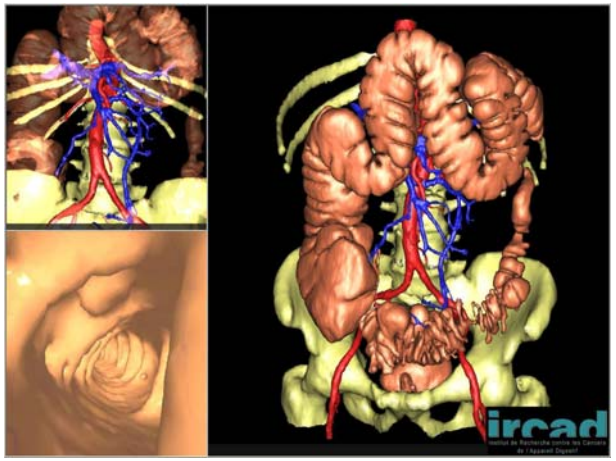


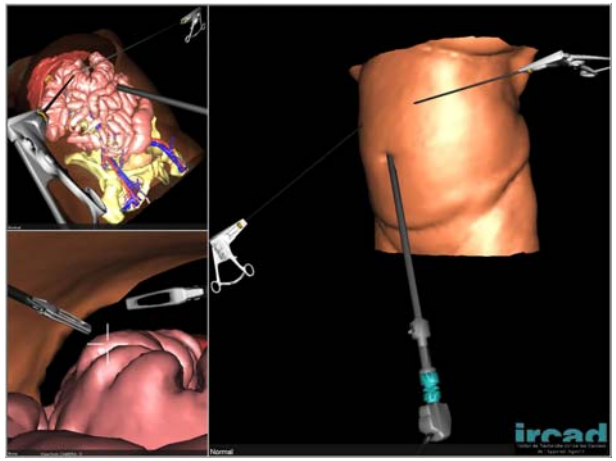
11% of CTs

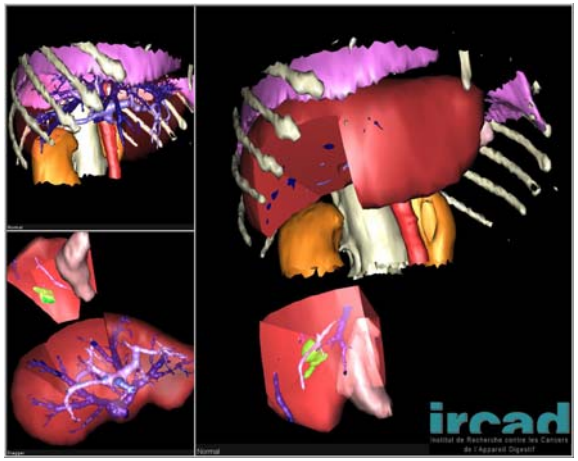
Step 3 : Surgical Planning



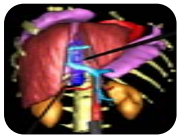
Surgical Planning





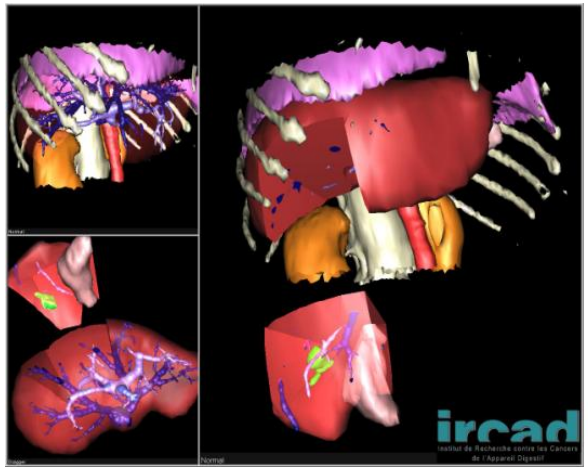


- Virtual navigation
- Virtual surgical tool positioning
- Virtual organ resection
- Volume computations

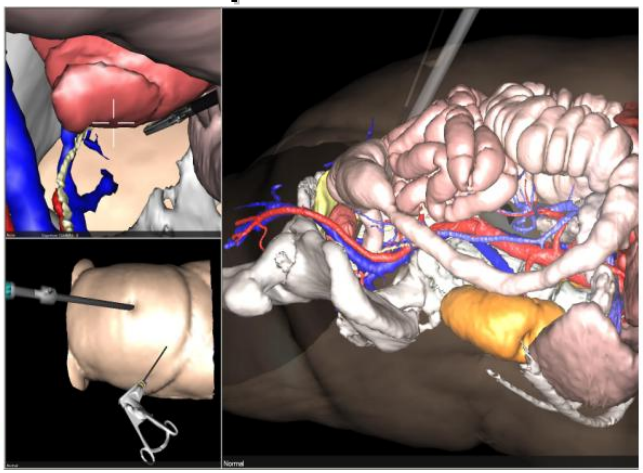


Surgical Planning

Virtual resection

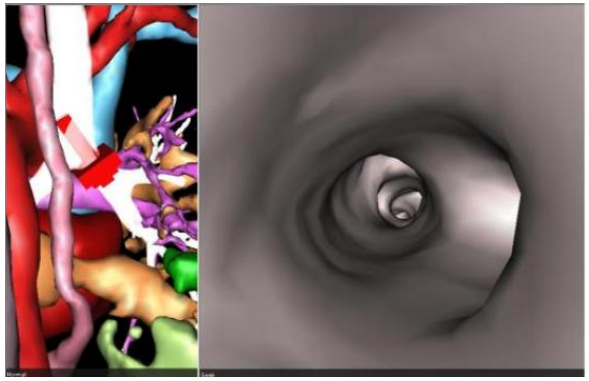


Tools placement

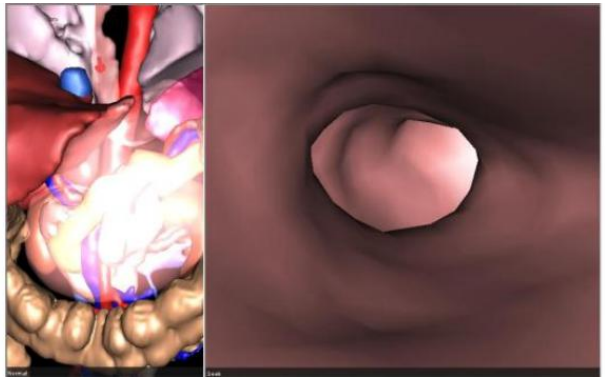


Intraoperative use

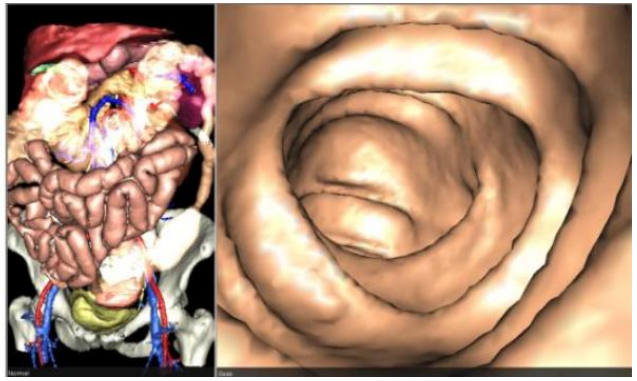
Virtual fibroscopy



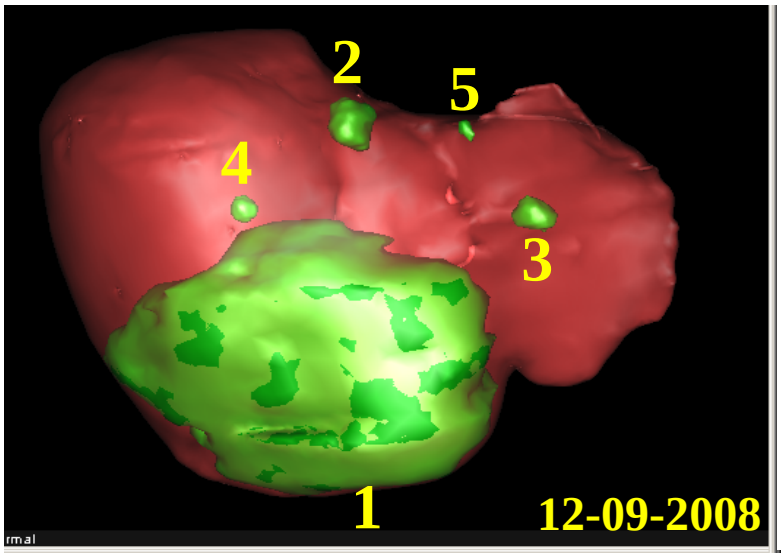
Virtual Gastroscopy



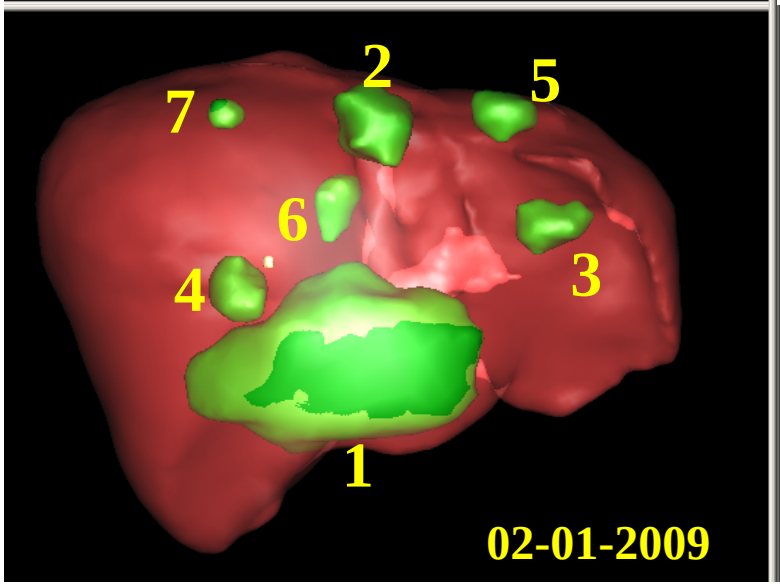
Virtual Colonoscopy



4D Modelling of Patients



Volumes en cc	12/09/2008	02/01/2009	03/04/2009	Evolution
Tumeur 1	420,00	82,60	41,00	↘ ↘
Tumeur 2	2,90	9,80	14,80	↗ ↗
Tumeur 3	1,10	3,50	1,12	↗ ↘
Tumeur 4	0,80	7,20	7,20	↗ →
Tumeur 5	0,10	2,60	4,10	↗ ↗
Tumeur 6	0,00	2,40	0,53	↗ ↘
Tumeur 7	0,00	0,30	0,08	↗ ↘
Total	424,90	108,40	68,83	↘ ↘



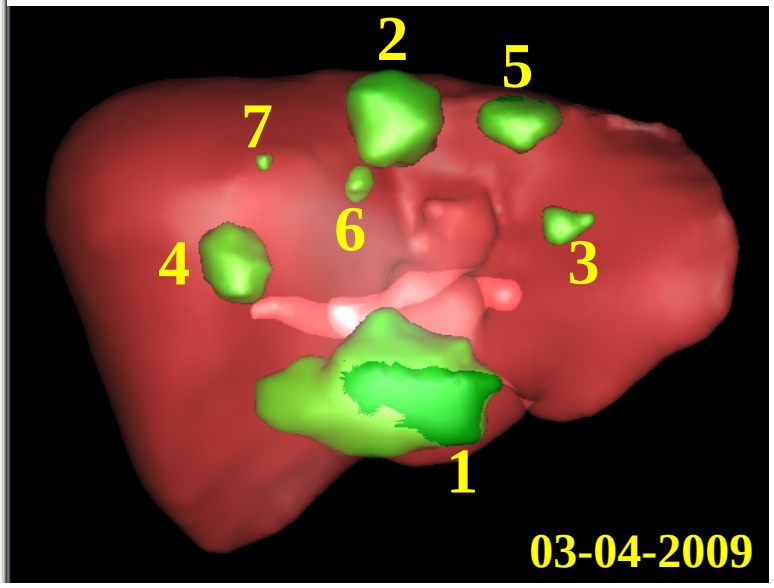
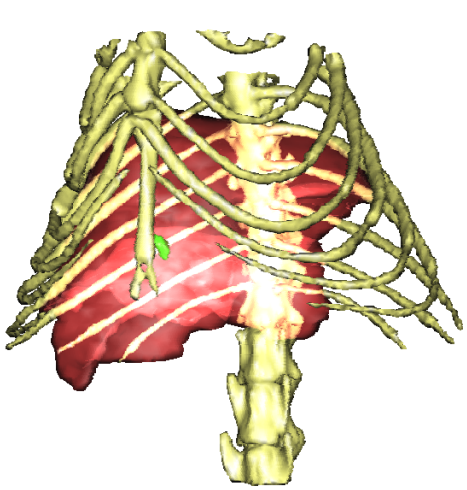
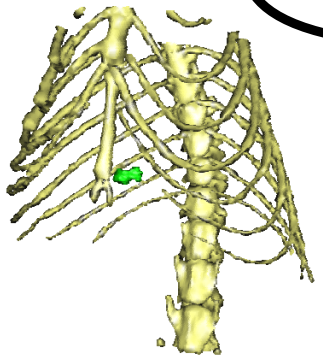


Image comparison

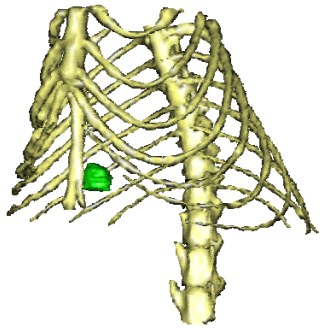
Liver tumor



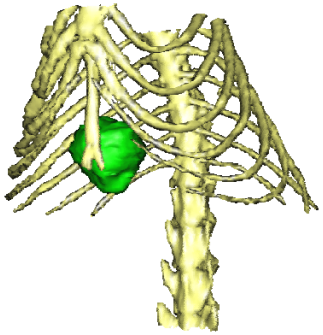
2 semaines



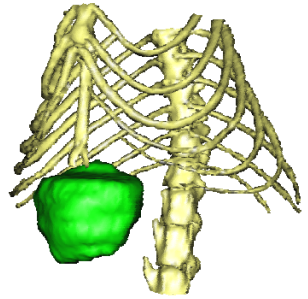
4 semaines



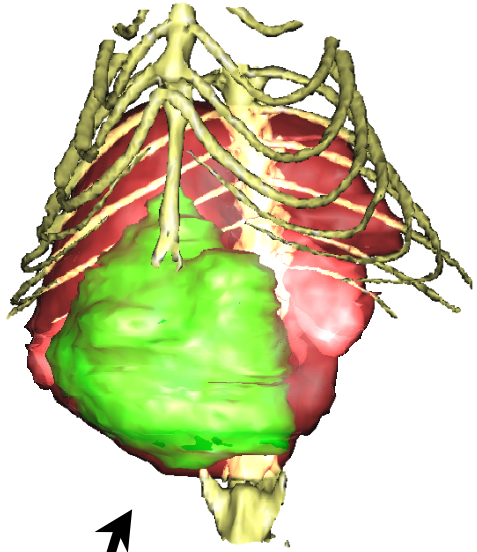
6 semaines



8 semaines



9 semaines



Step 4 : Surgical Simulation

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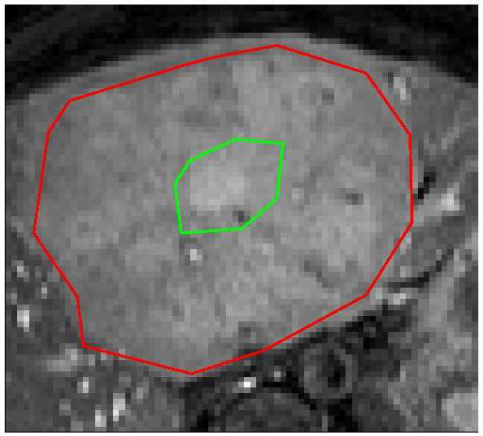
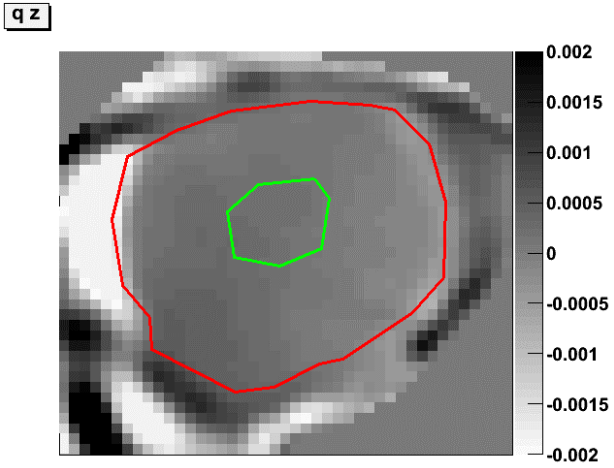
Mechanical modeling

@Health

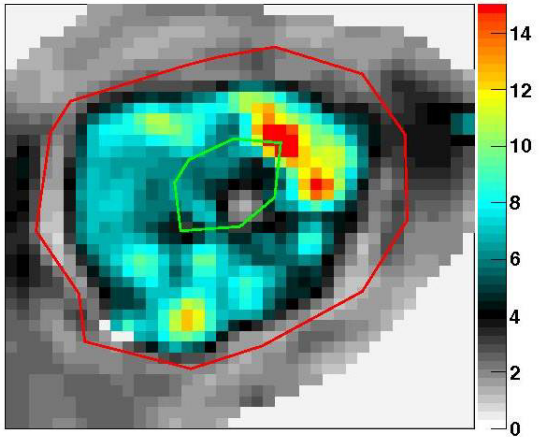
Magnetic Resonance Elastography



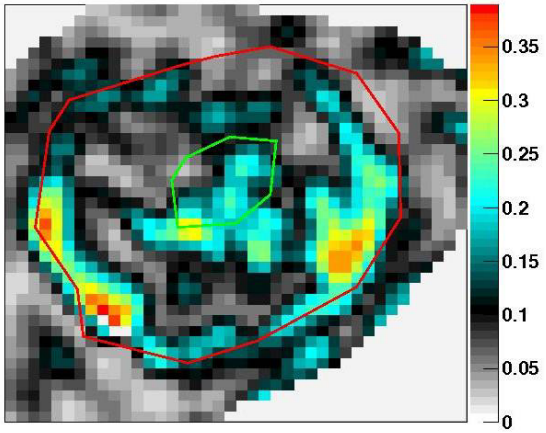
anatomy



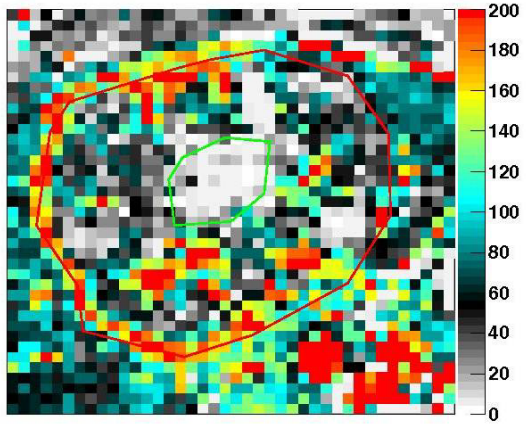
shear waves



elasticity [kPa]



liquid/solid ratio



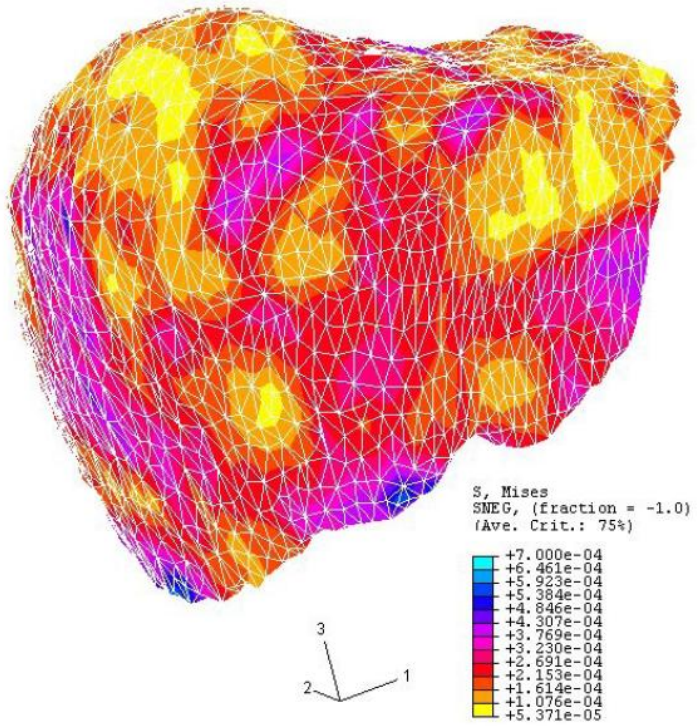
gadolinium enhancement[%]

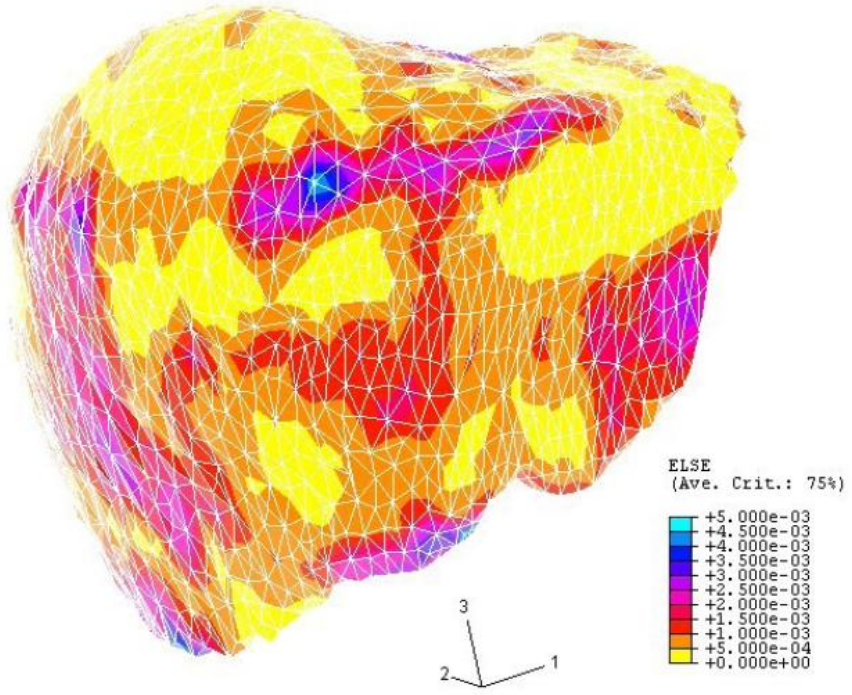
Prof. Van Beers, Ralph Sinkus Hôpital Beaujon, INSERM 773

PASSPORT

Mechanical modeling

@Health





Elasticity 3D map : IRCAD + IMFS (UDS/CNRS)

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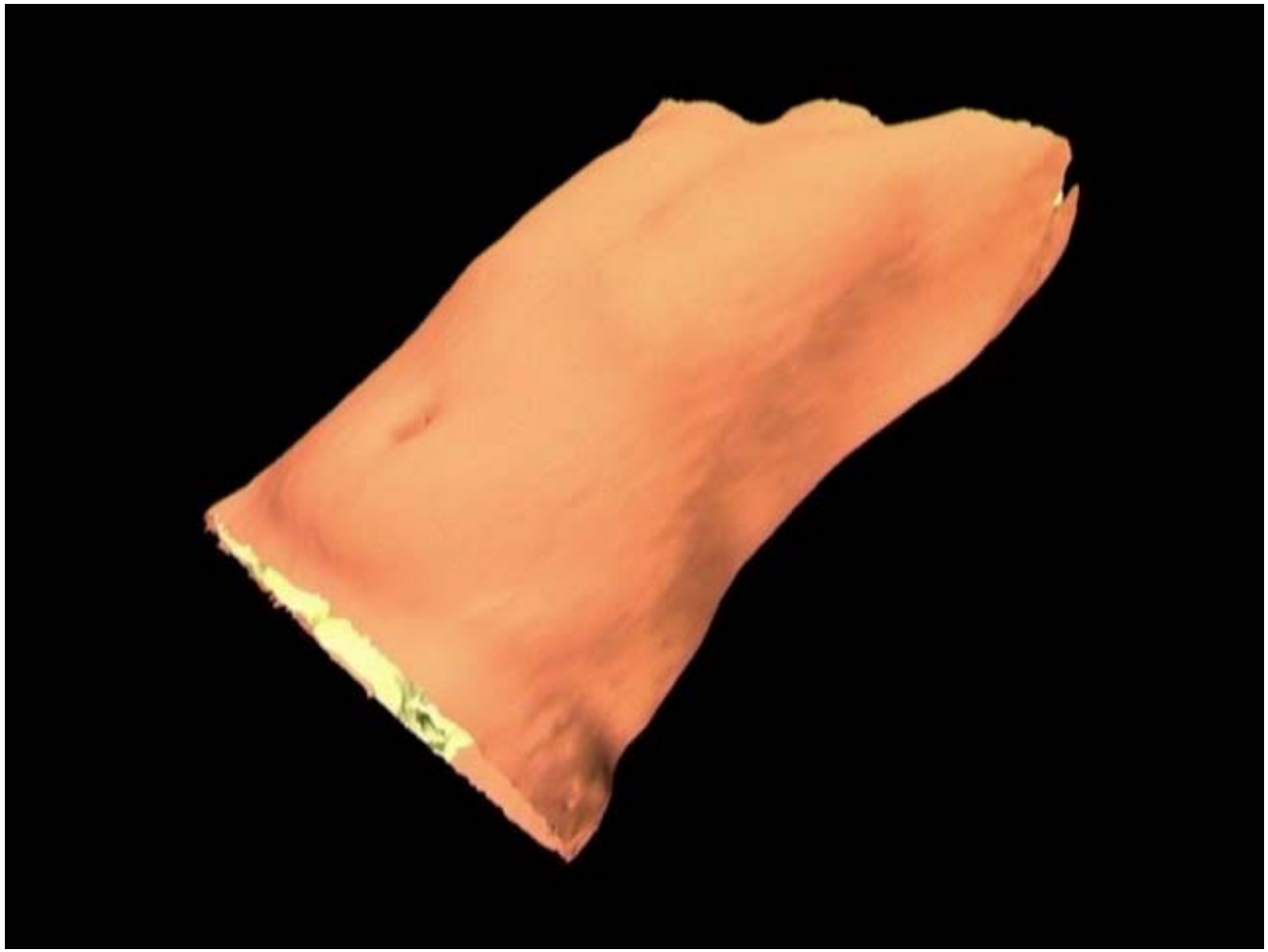
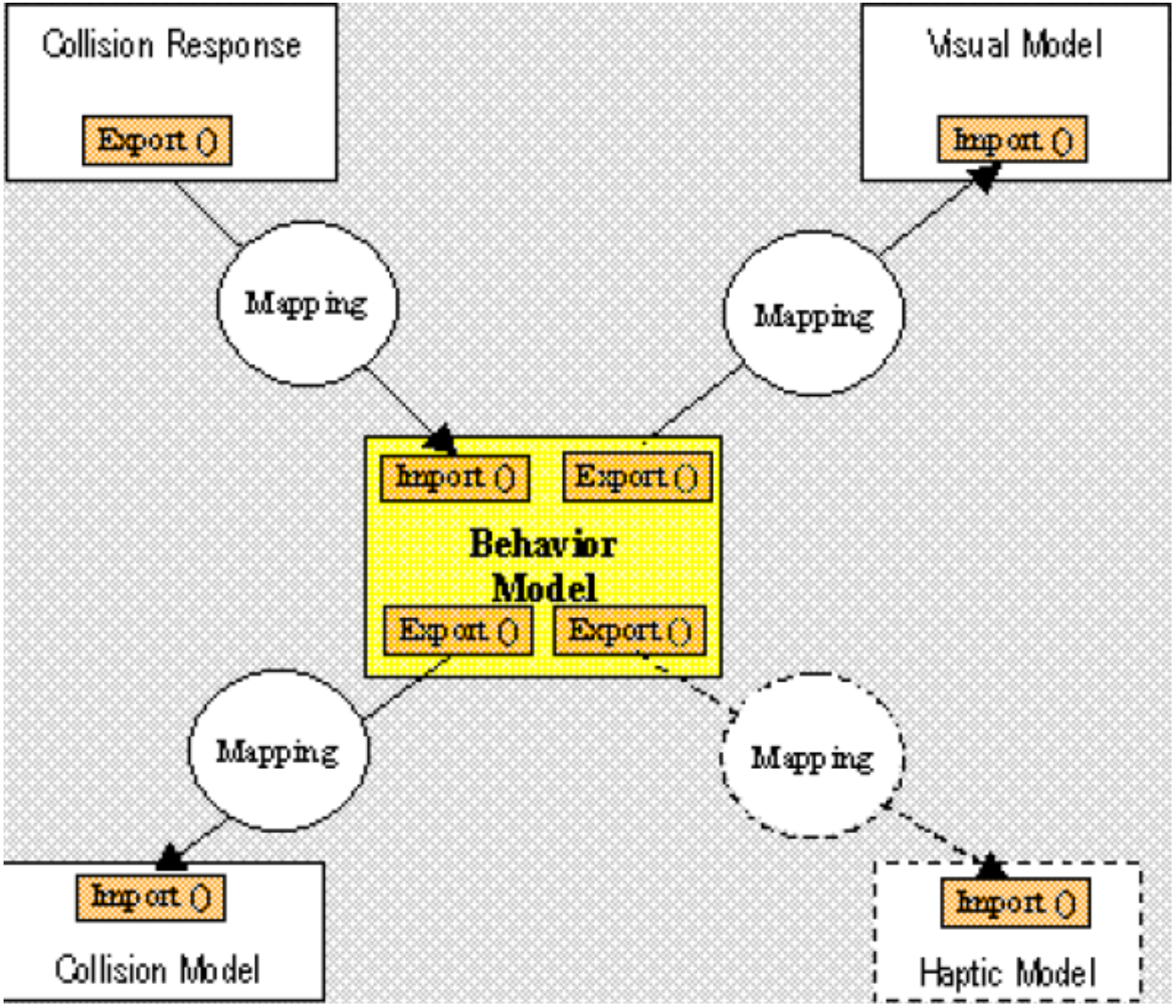
Dynamic modelling

@Health



Patient-specific organ motion simulation

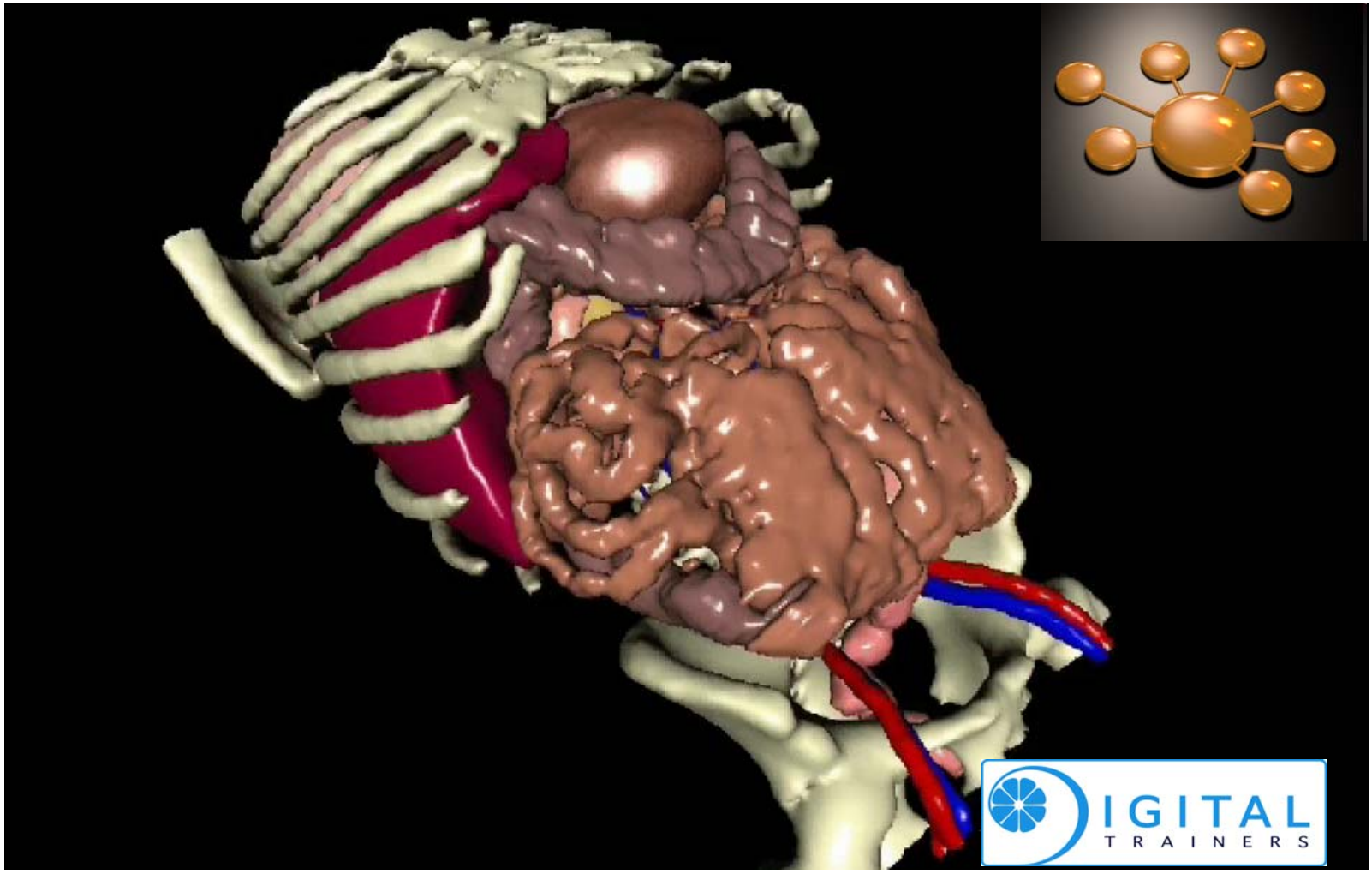
SOFA : www.sofa-framework.org



INRIA

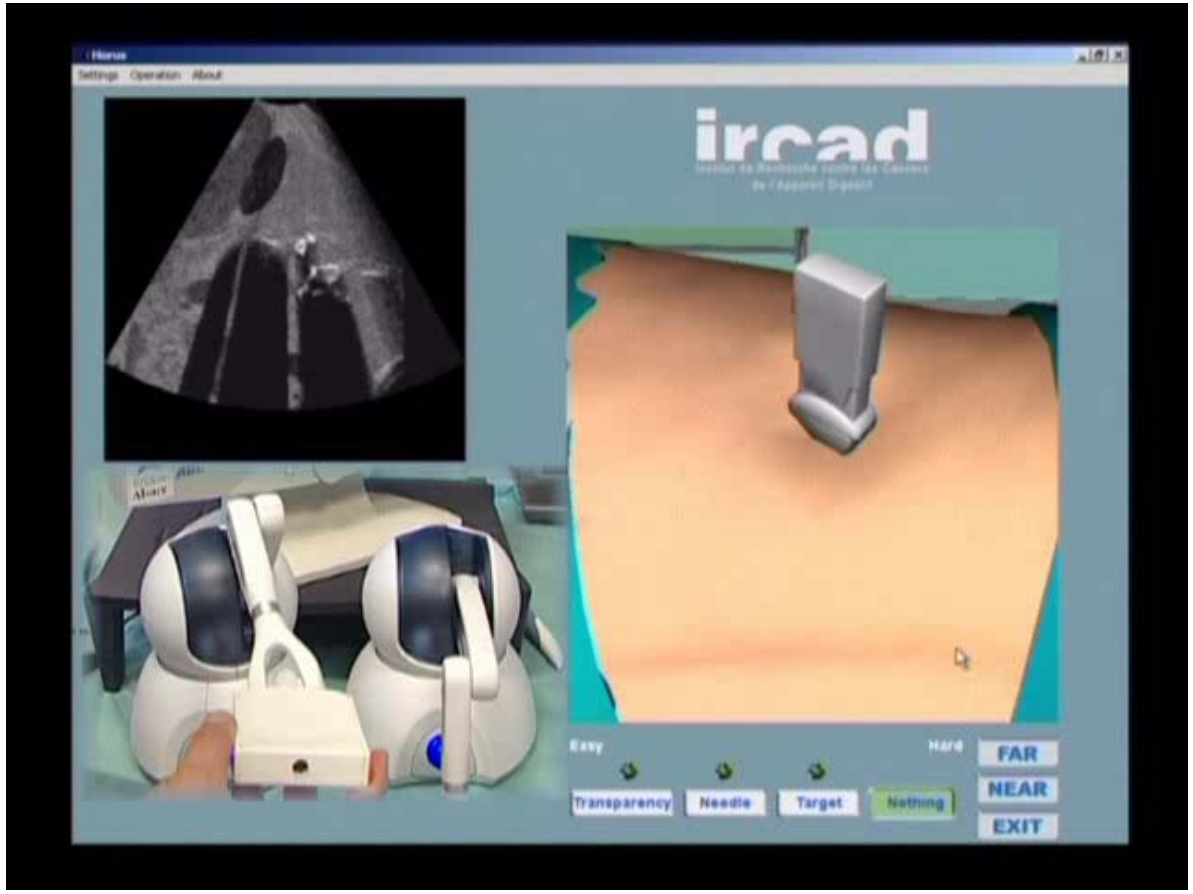
Alcove, Asclepios and Evasion

Integration of patient models : SOFA



Patient Specific Integrated model

HORUS : Ultrasonography simulator



Ultrasonographic guided procedure
from patient CT-Scan

ULIS : Laparoscopic Simulator

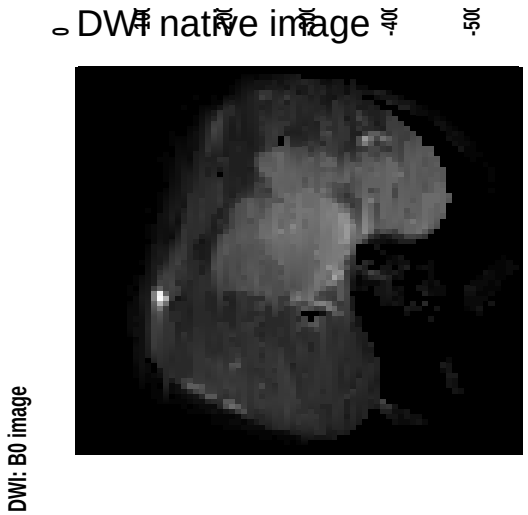
IRCAD's Spin-off : Digital Trainers

PASSPORT

Biological modeling

eHealth

Diffusion MRI

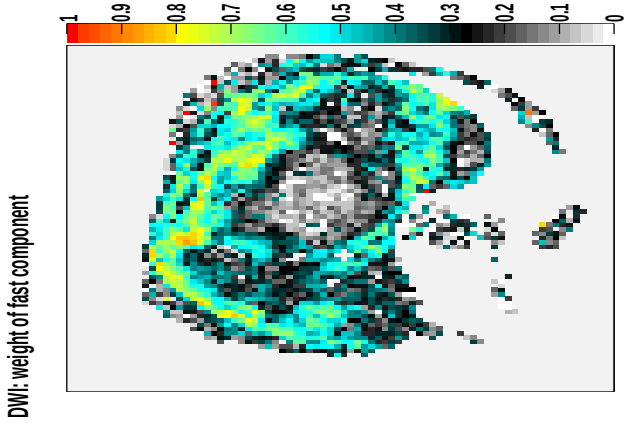


Cholangiocarcinoma

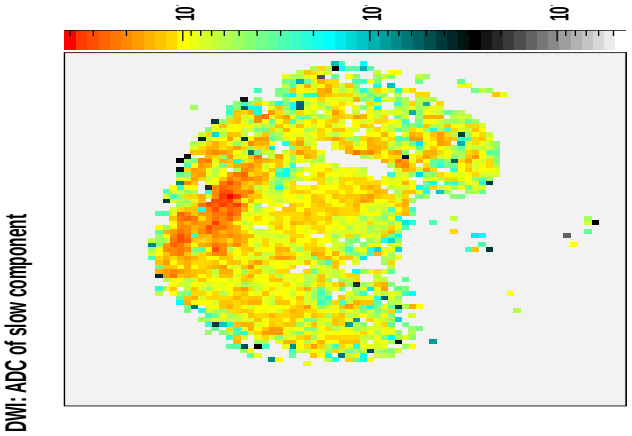
Parenchyma:
D*=29.5 mm2/sec, f=28.9%

Tumor:
D*=1.17 mm^2/sec, f=4.89%

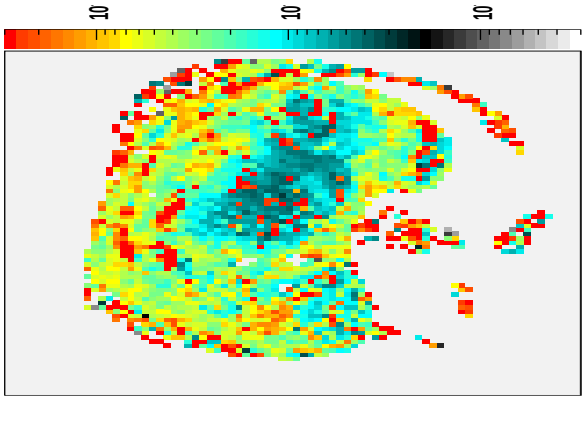
f: Fraction of the diffusion linked to the microcirculation



D: Pure diffusion



D*: Perfusion related diffusion

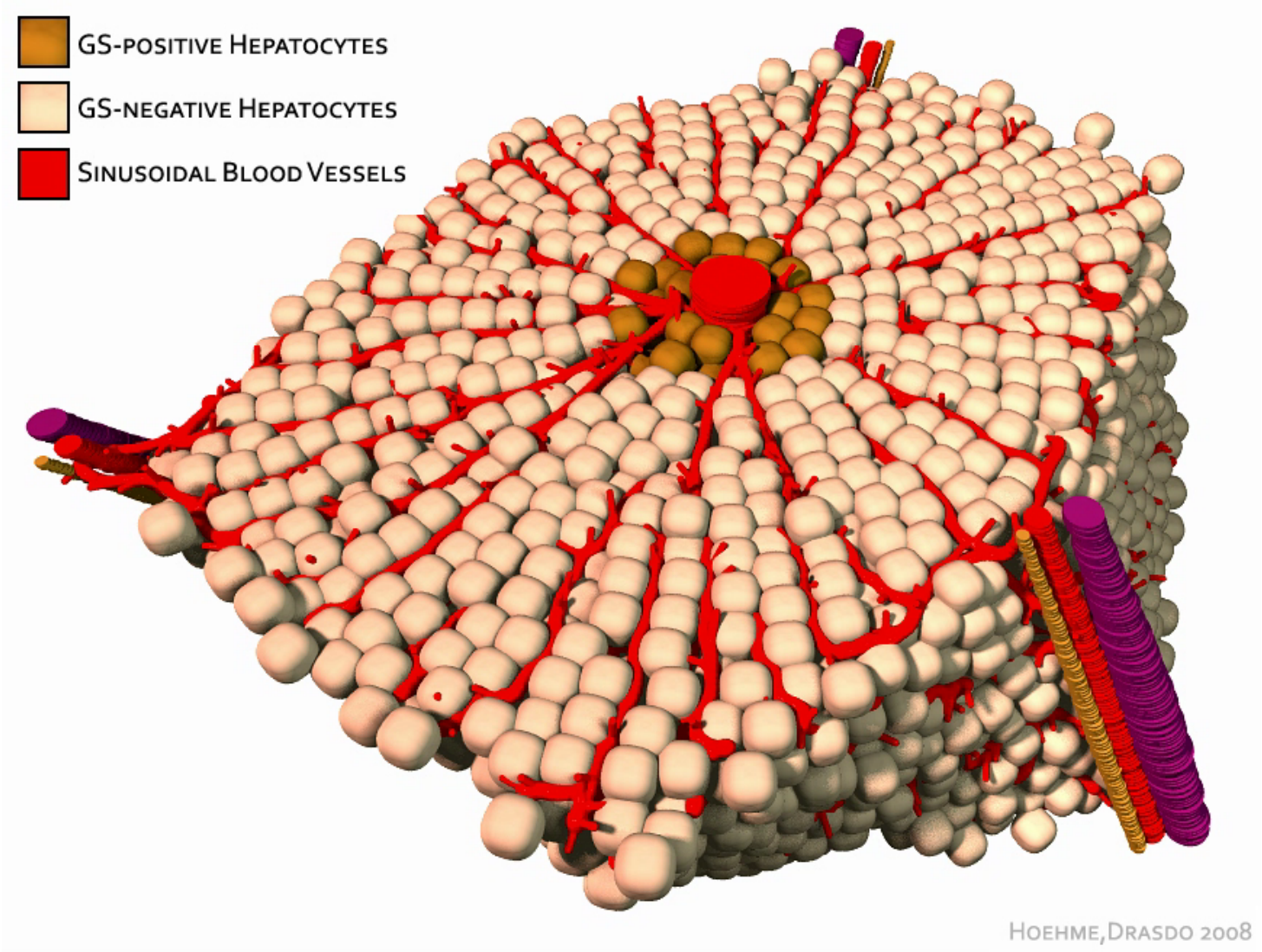


Prof. Van Beers, Ralph Sinkus Hôpital Beaujon, INSERM 773

PASSPORT

Regeneration modelling

INRIA IZBI

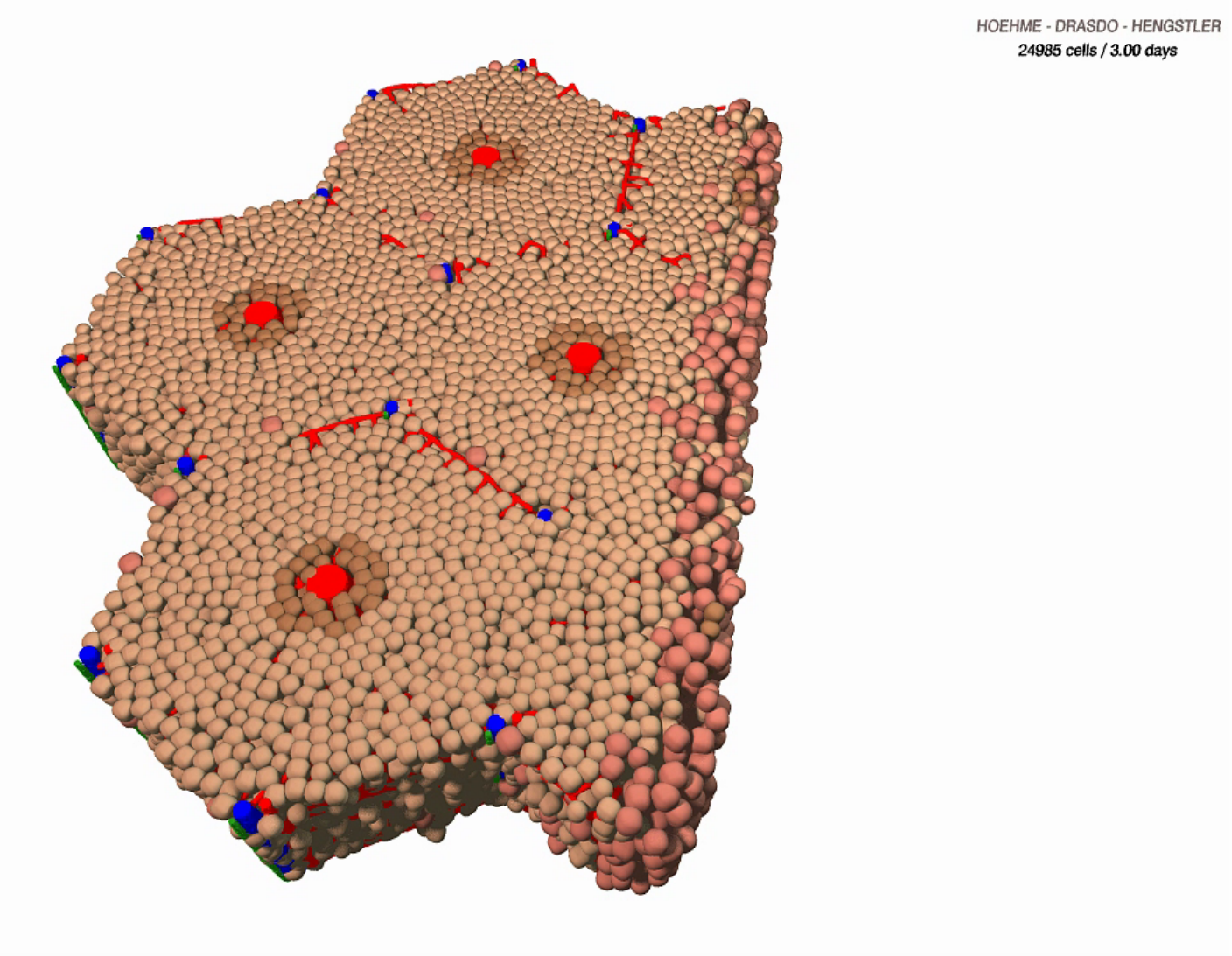


Regeneration after CCl_4 intoxification

PASSPORT

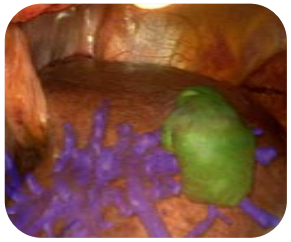
Regeneration modelling

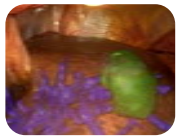
INRIA IZBI



Regeneration after surgical resection

Step 5 : Augmented Reality

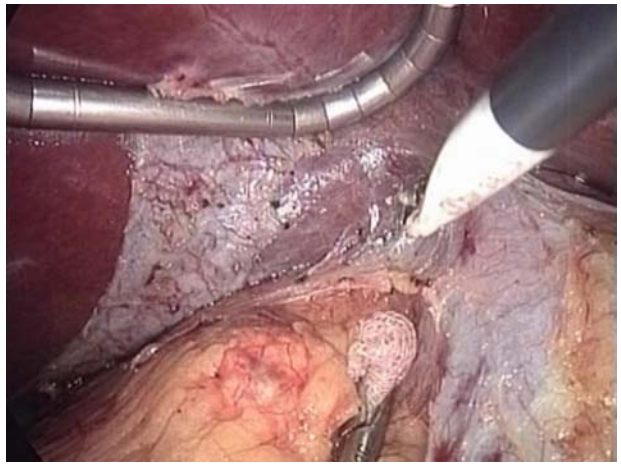




Augmented Reality

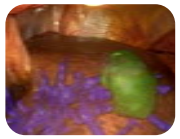
Real Views

Out **In**



Virtual Views

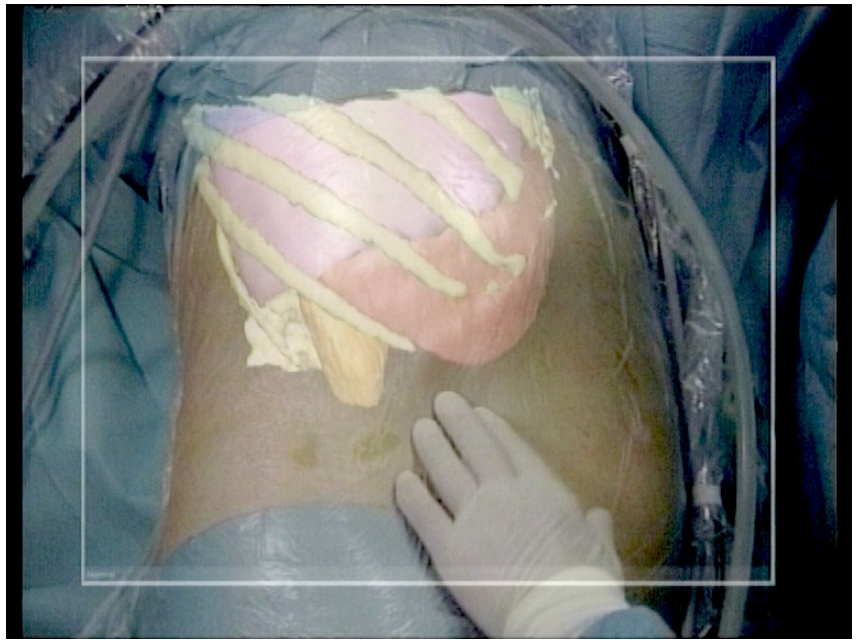
Out **In**



Augmented Reality

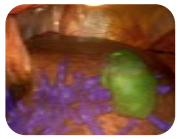
Augmented Reality Views

Out



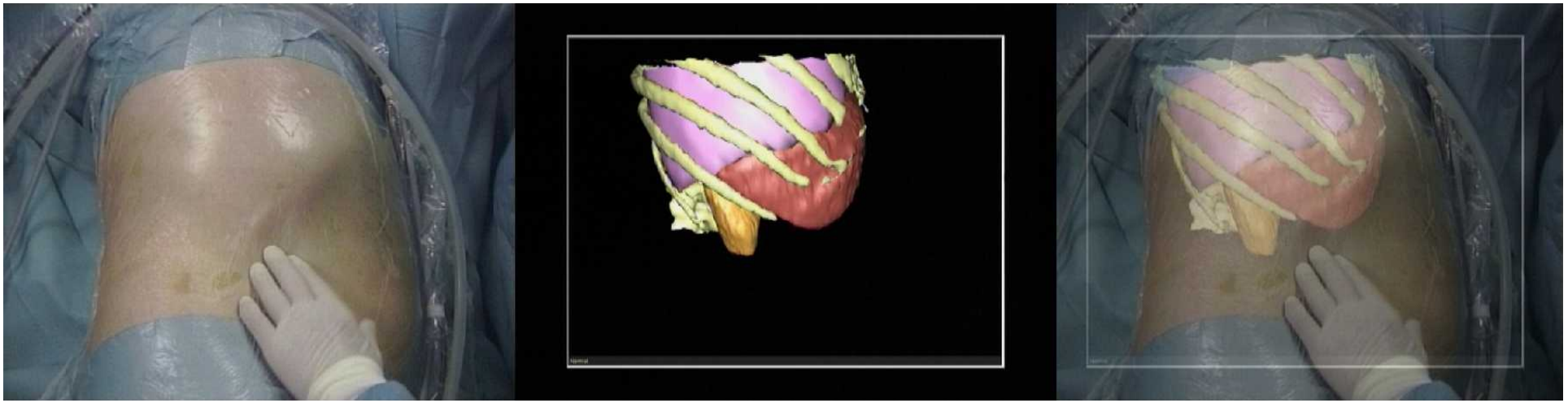
In

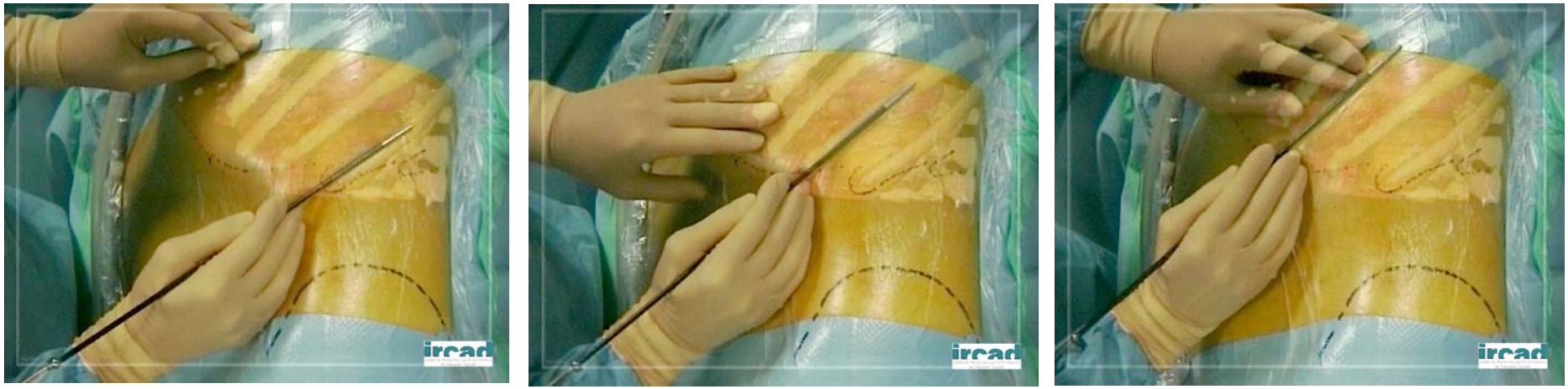
Data Fusion



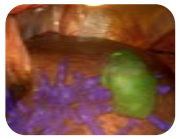
Interactive Augmented Reality

Interactive Augmented Reality



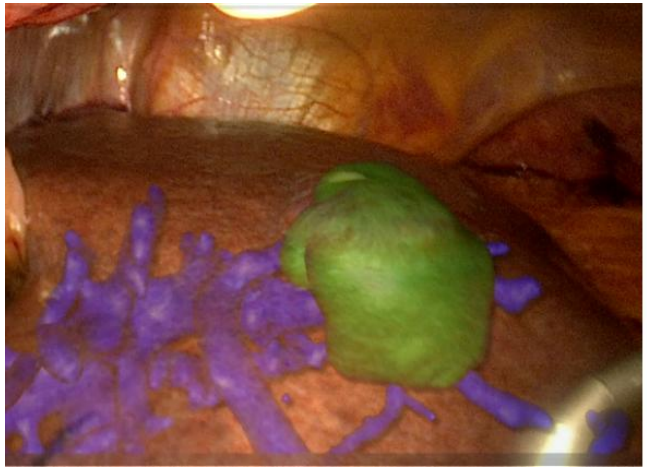


Adrenal Surgery : JAMA November 2004



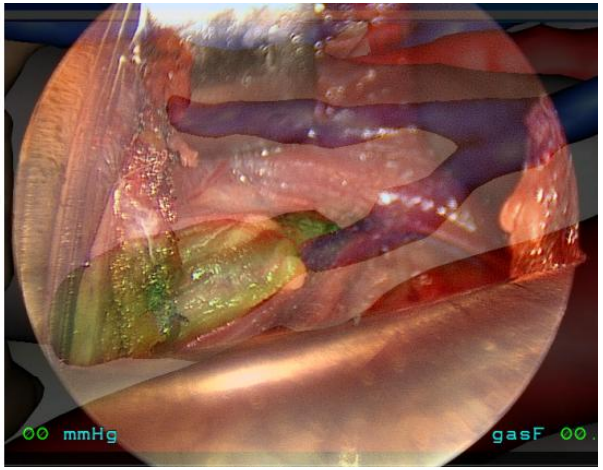
Interactive Augmented Reality

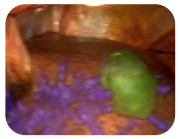
Hepatic surgery



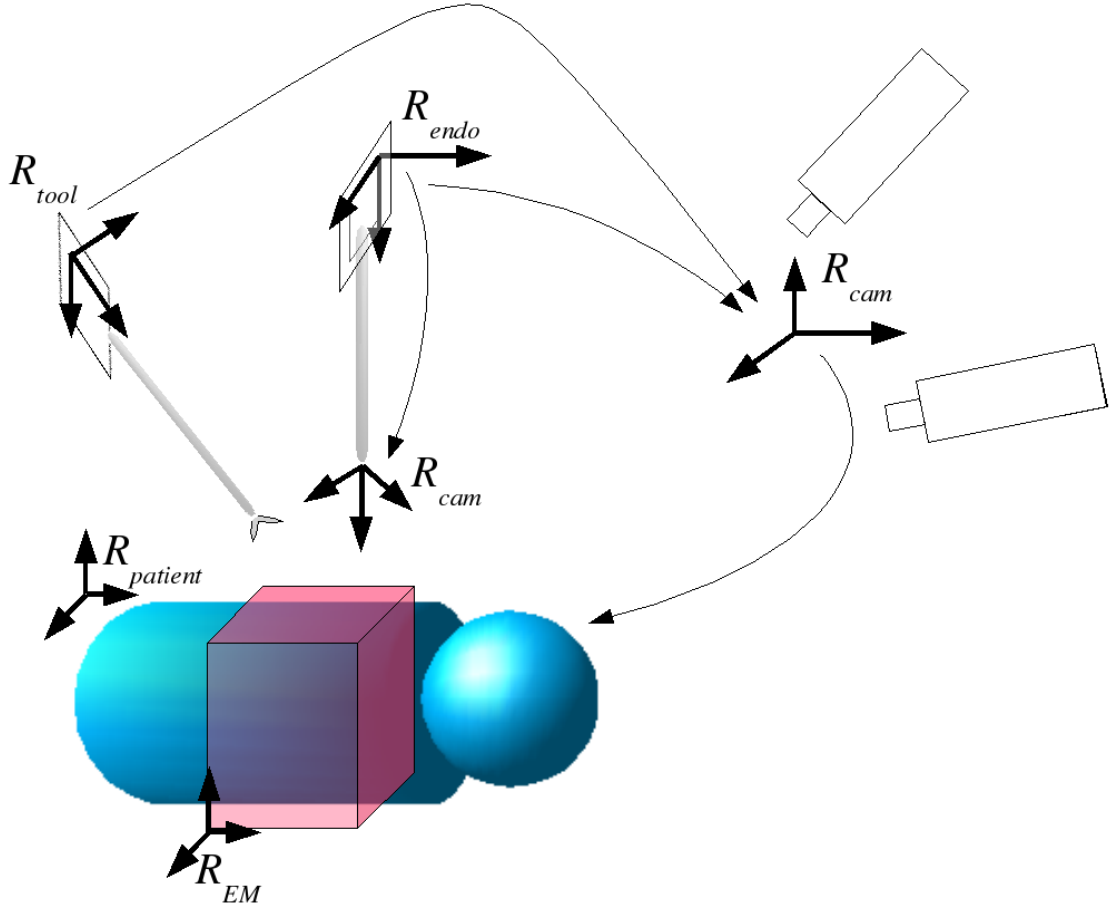
Pancreatic Surgery

Parathyroid Surgery

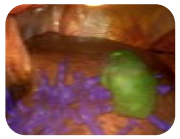




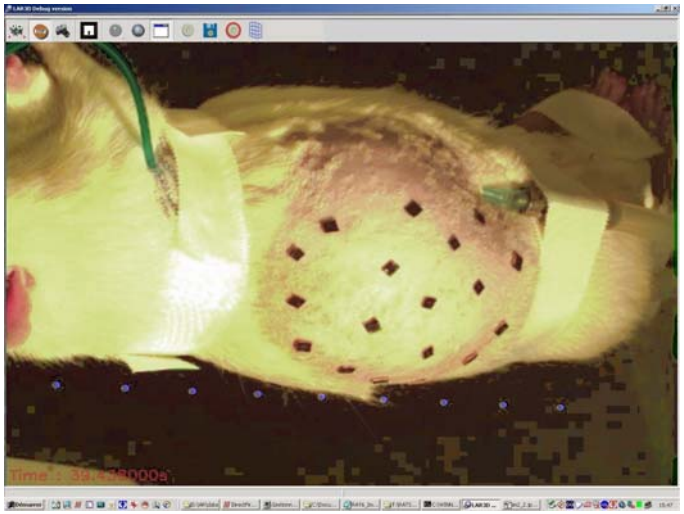
Automated Augmented Reality

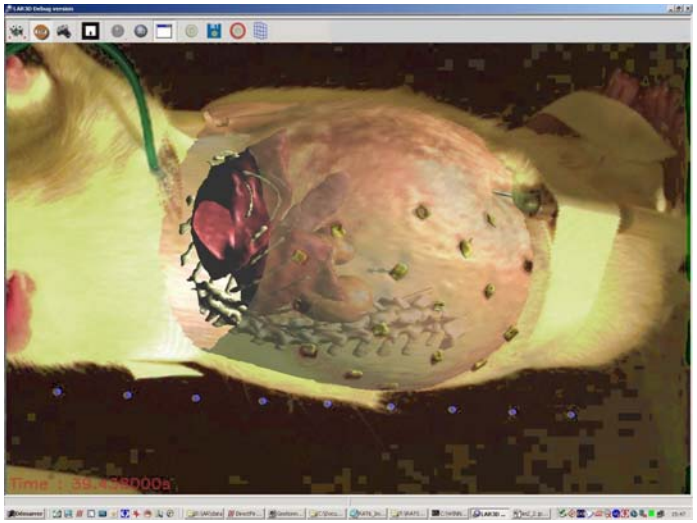


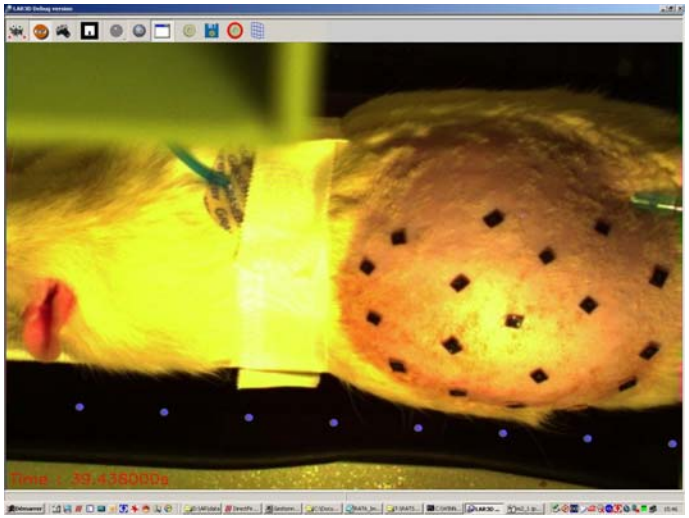
2 axes ➔ Calibration & Registration

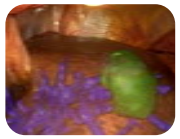


Automatic Augmented Reality



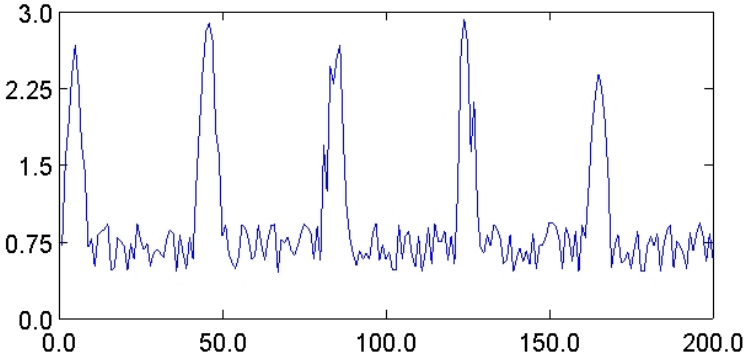


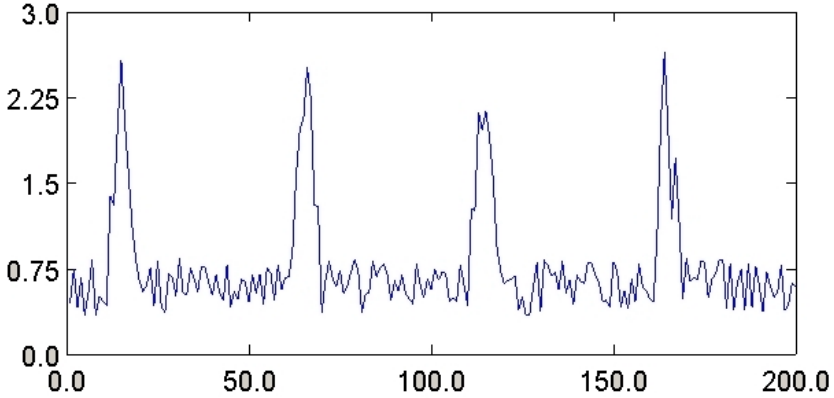




Automatic Augmented Reality

- Evaluation of System precision on 5 rats





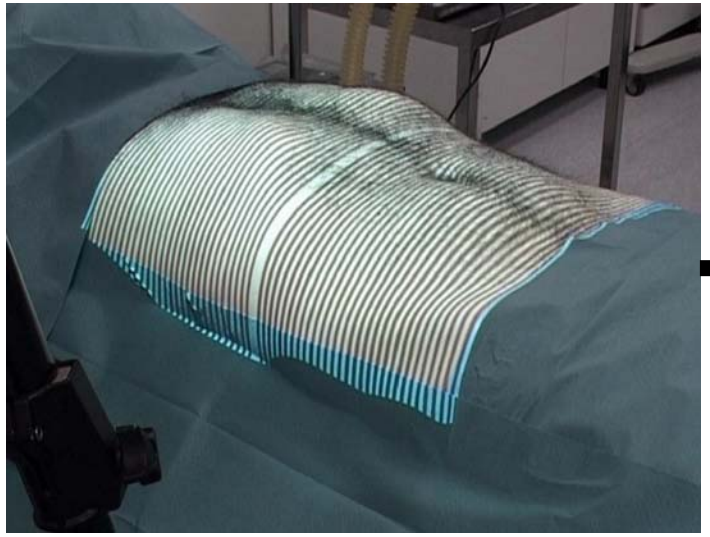
Rat number	1	2	3	4	5
System error (mm)	0.76 ± 0.06	0.85 ± 0.05	0.63 ± 0.04	0.82 ± 0.04	0.68 ± 0.05

Average system error of 0.75 mm

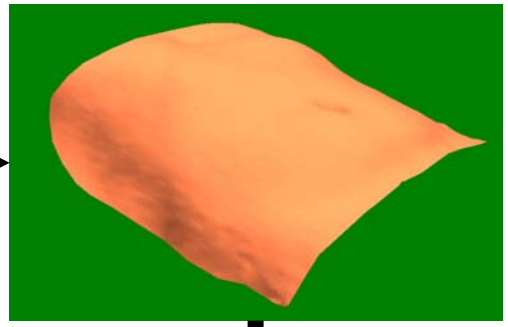
PASSPORT

Movement tracking

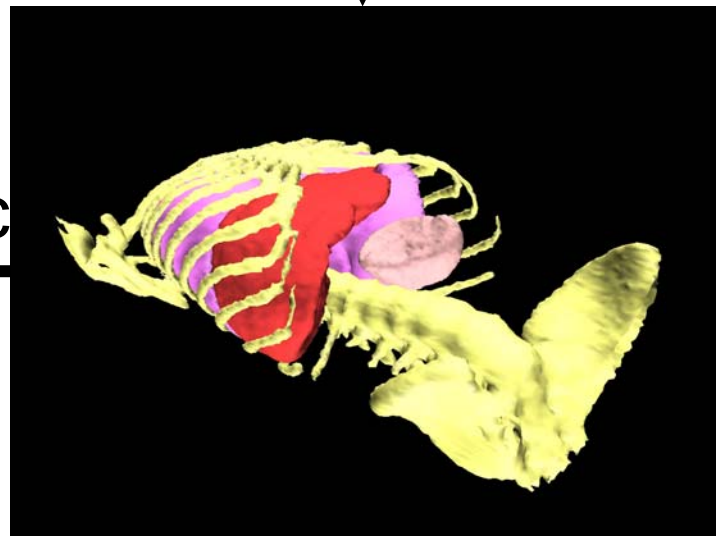
eHealth



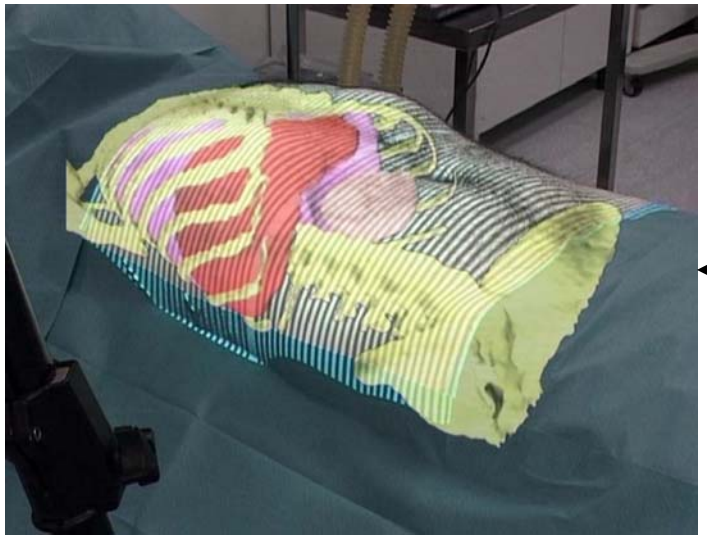
Automatic surface extraction



Automatic Registration



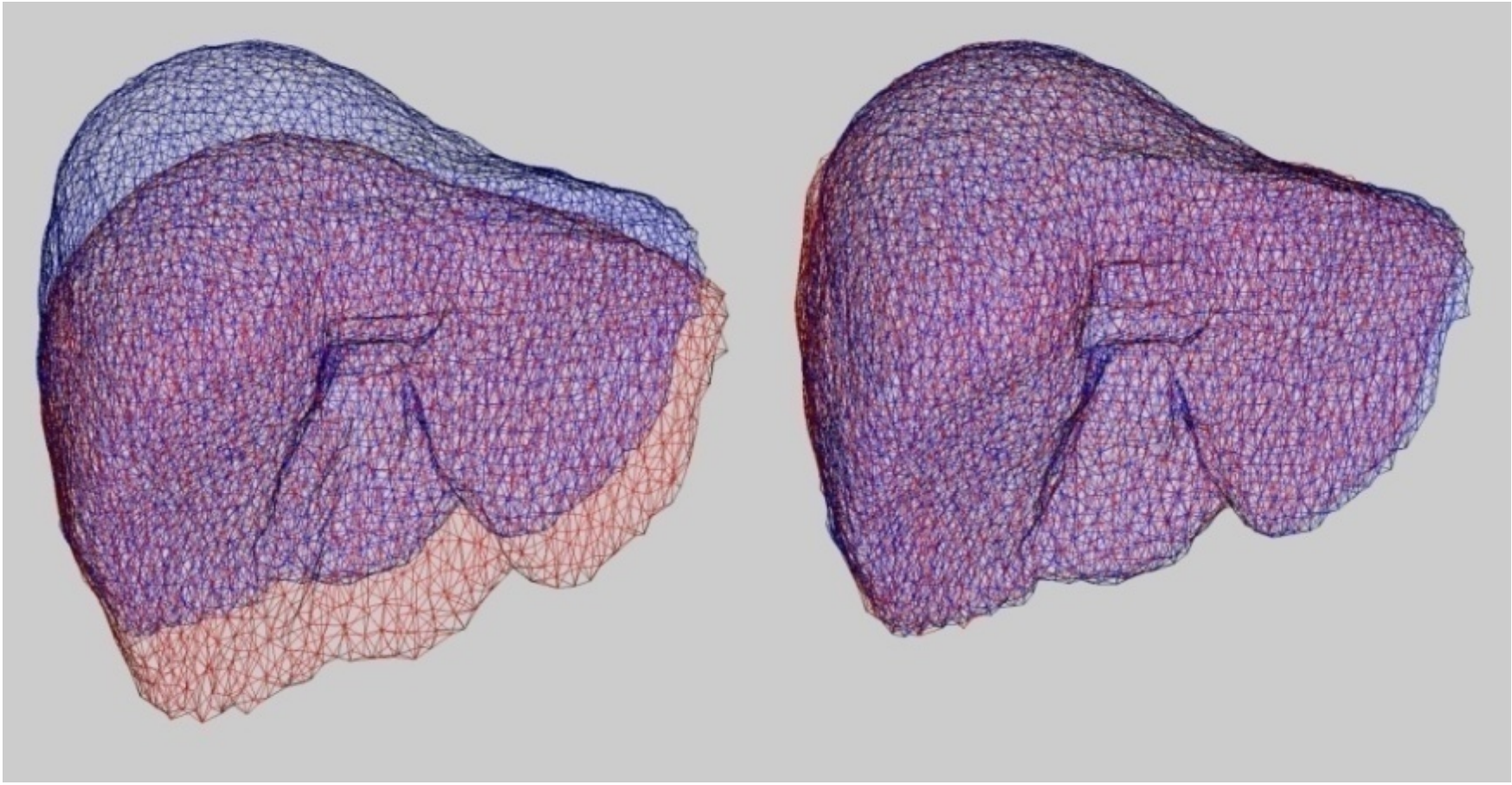
Automatic AR



PASSPORT

Movement tracking

eHealth



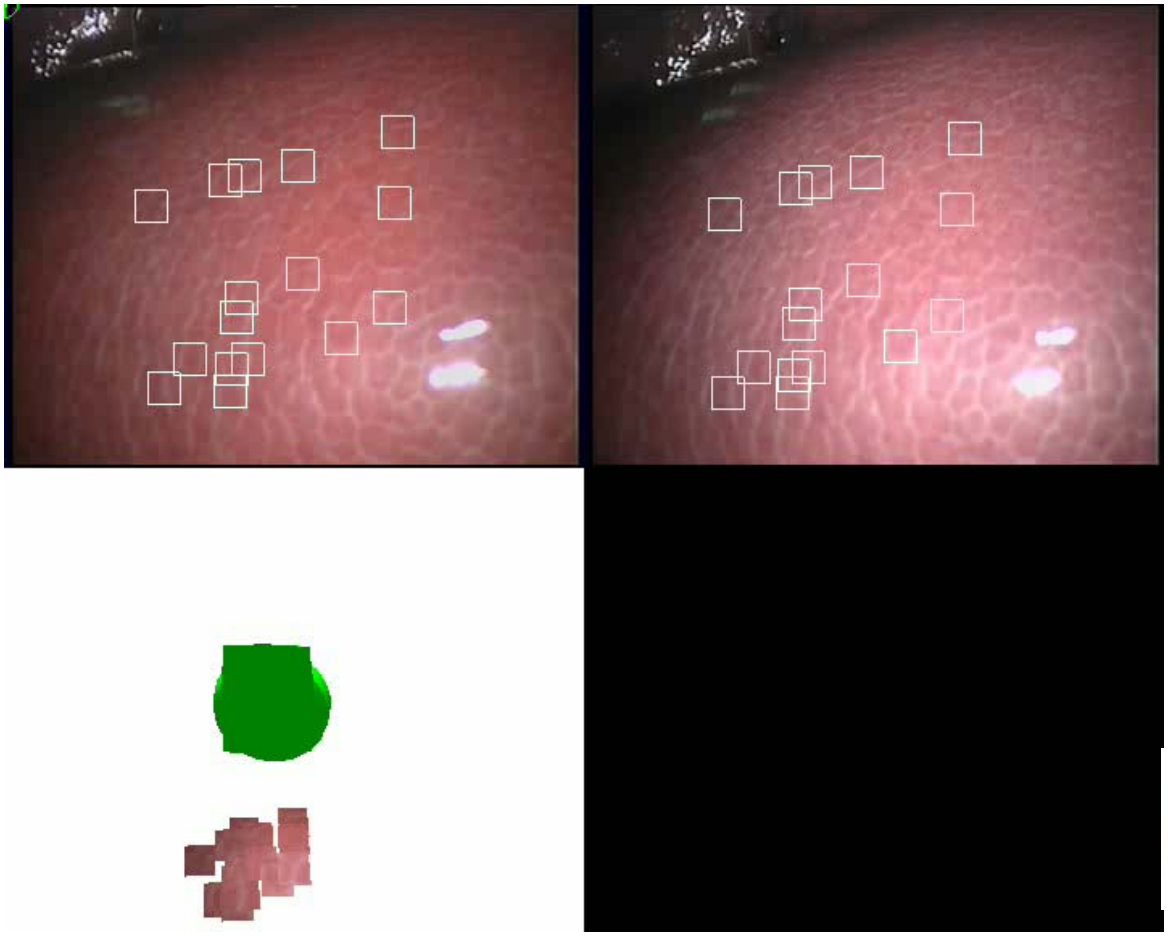
Accuracy = 2 mm for liver (1.3 for kidneys)

PASSPORT

Movement Tracking

eHealth

Extracting motion model from Endoscopic data



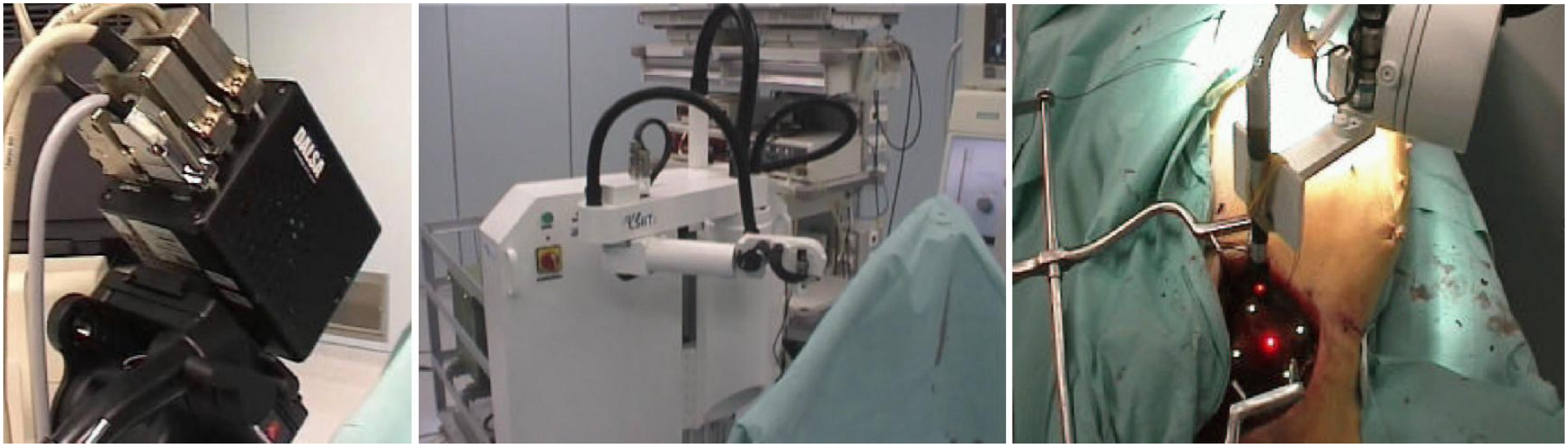
Imperial College London

Peter Moutney & Guang-Zhong Yang, ICL

Step 6 : Robotics

Robotics → Automation

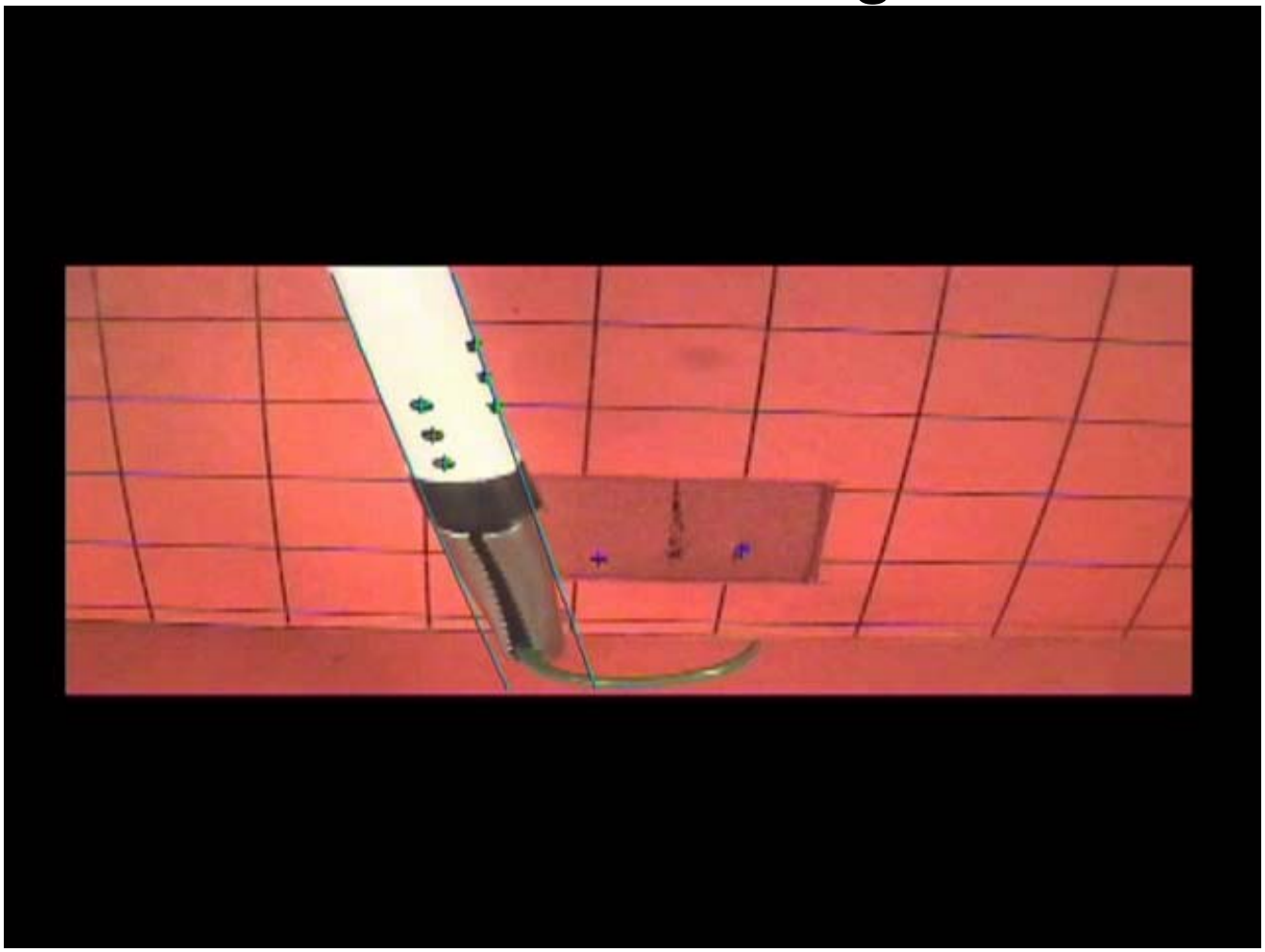
Visual Servoing



LSIIT Robotic team of Michel de Mathelin, IRCAD/ Strasbourg university

Robotics → Automation

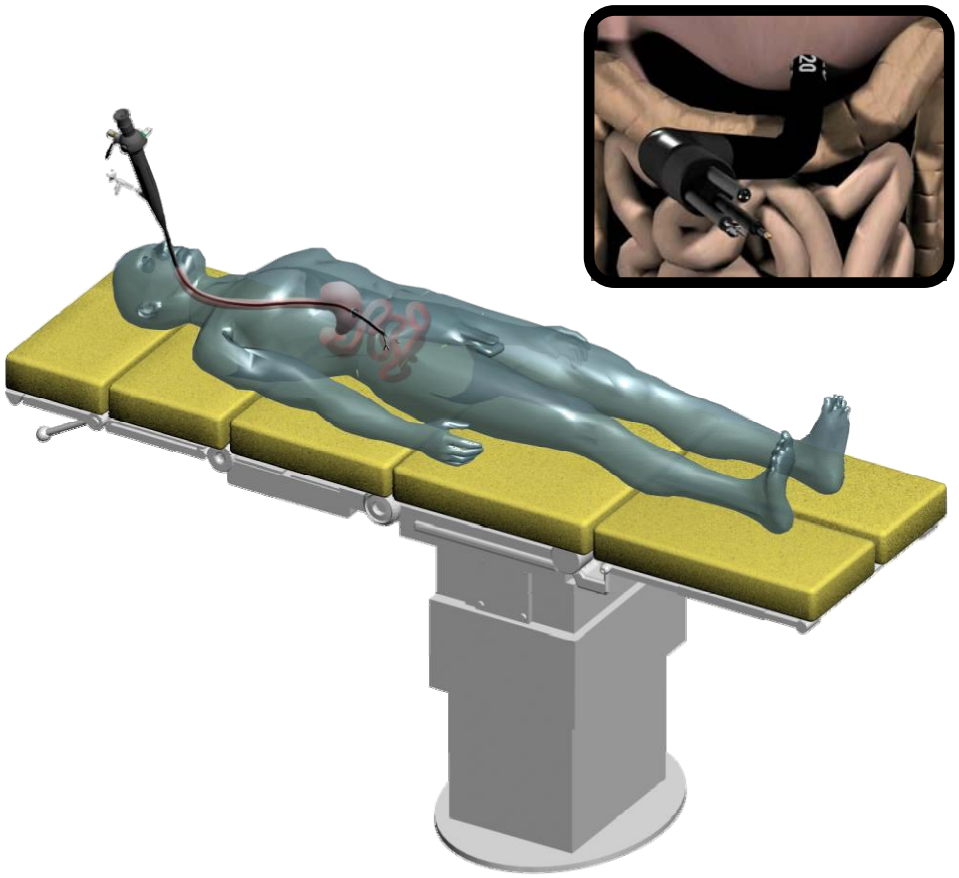
Visual Servoing



LSIIT Robotic team of Michel de Mathelin, IRCAD/ Strasbourg university

VR, AR & Robotics applied to NOTES

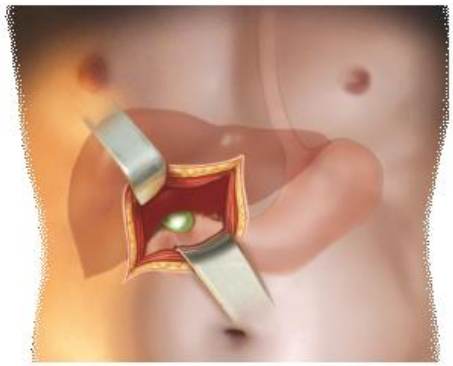
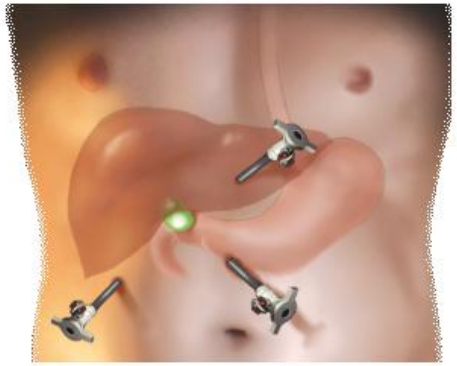
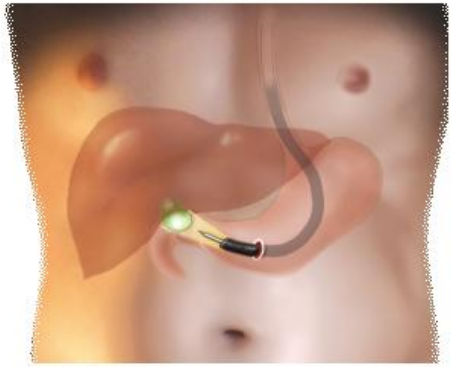
ANUBIS Project : 2005-2008



ISIS ➔ 2009-2012

ISIS : The ASET Project

Abdominal Single Endoscopic Trocar Surgery


Open laparoscopic NOTES ASET

ircad
Institut de Recherche contre les Cancers de l'Appareil Digestif

STORZ
KARL STORZ—ENDOSKOPE

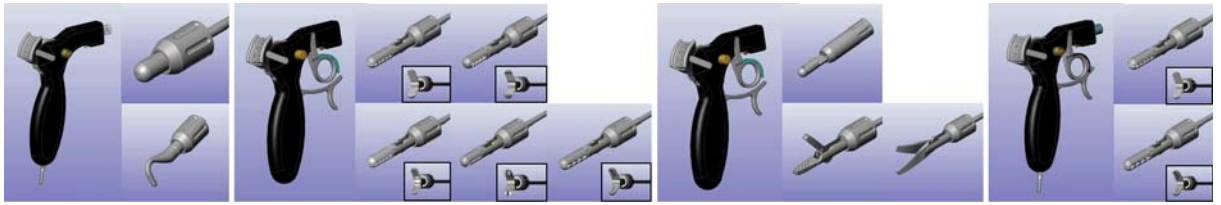
PROTOMED

UNIVERSITÉ DE STRASBOURG

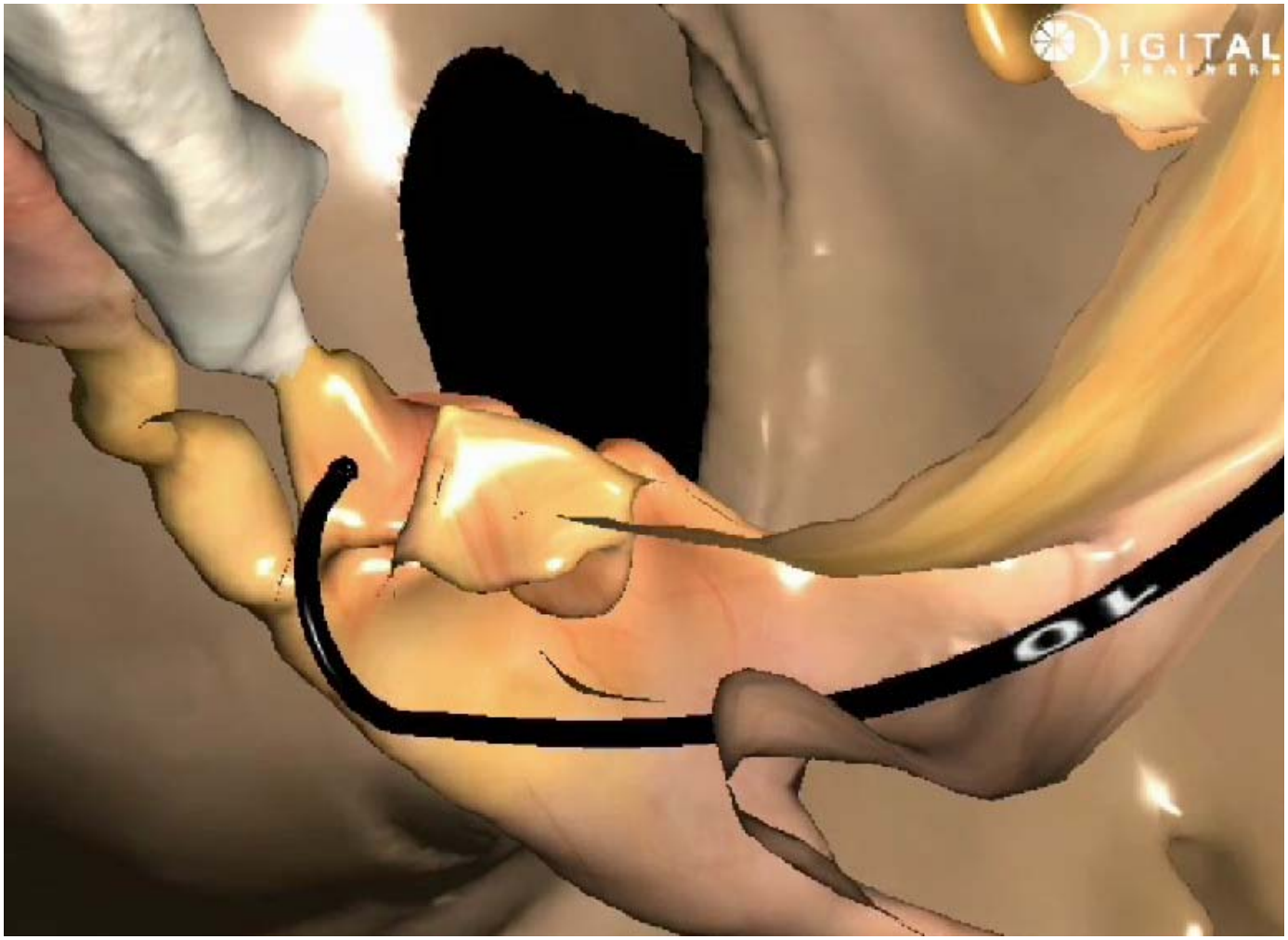
Aim : Improve instruments & control

Before ...

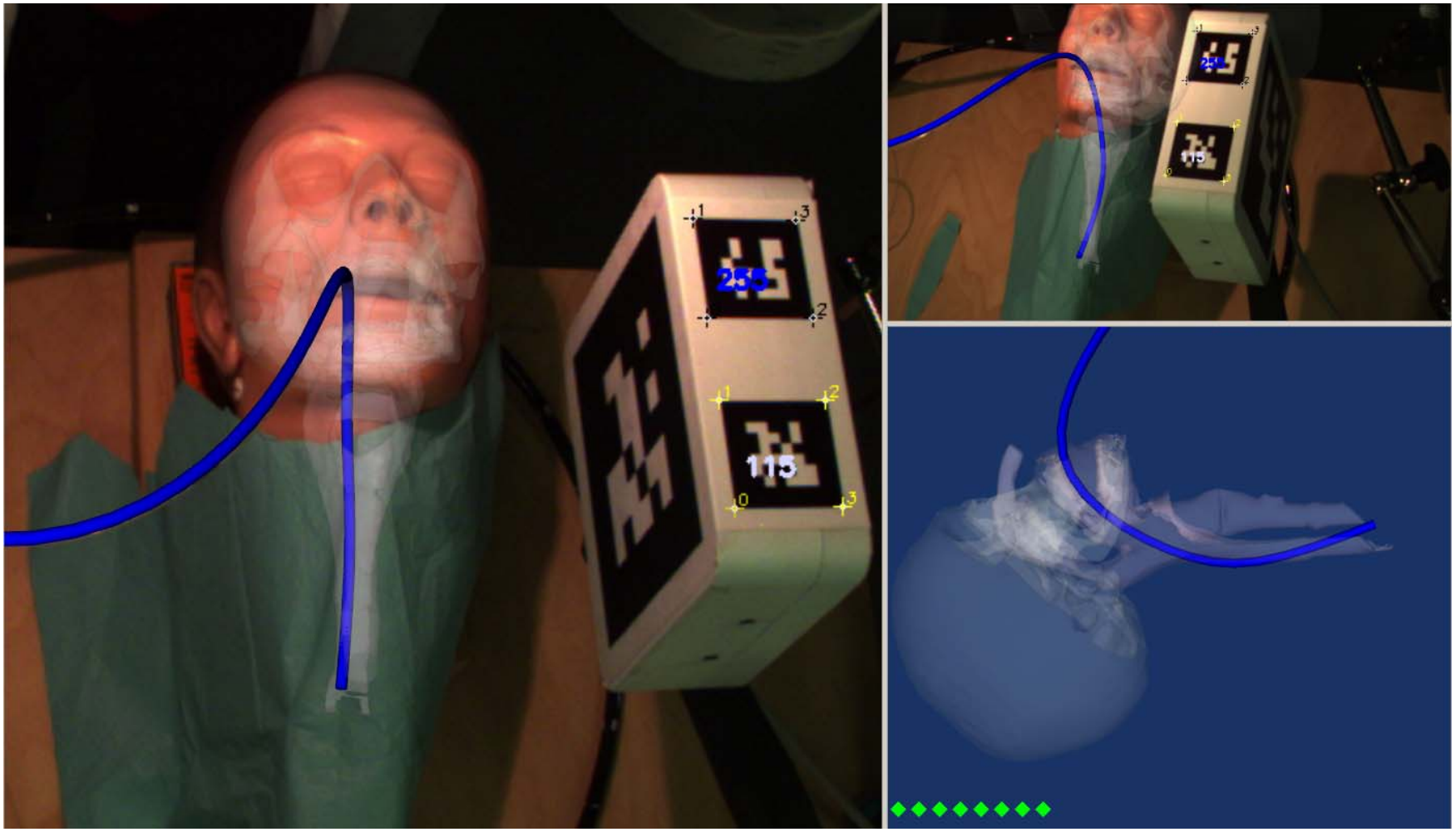
Now ...



Patient Specific NOTES Simulator



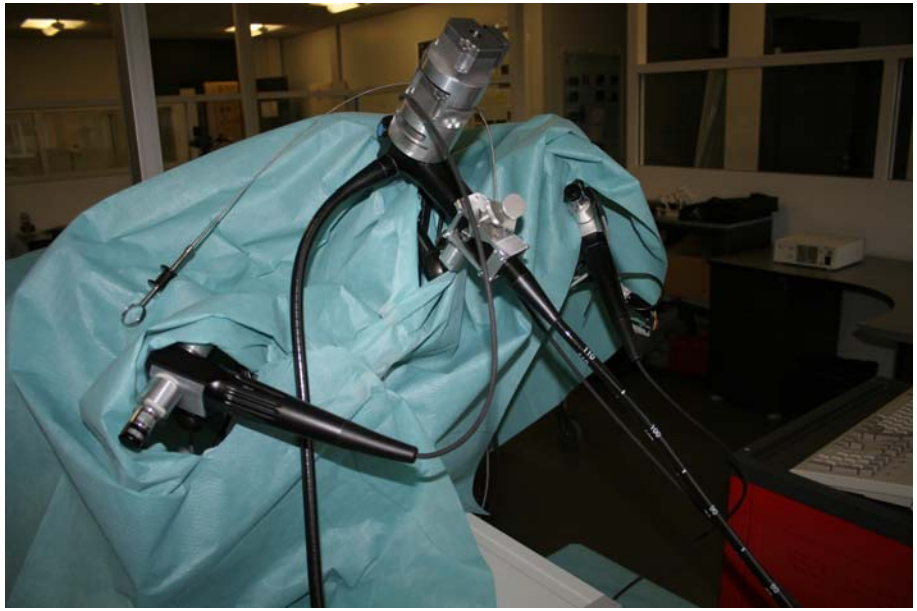
VR & AR : Simplest instrument control



METRIS

External Motors : Endoscope Robot

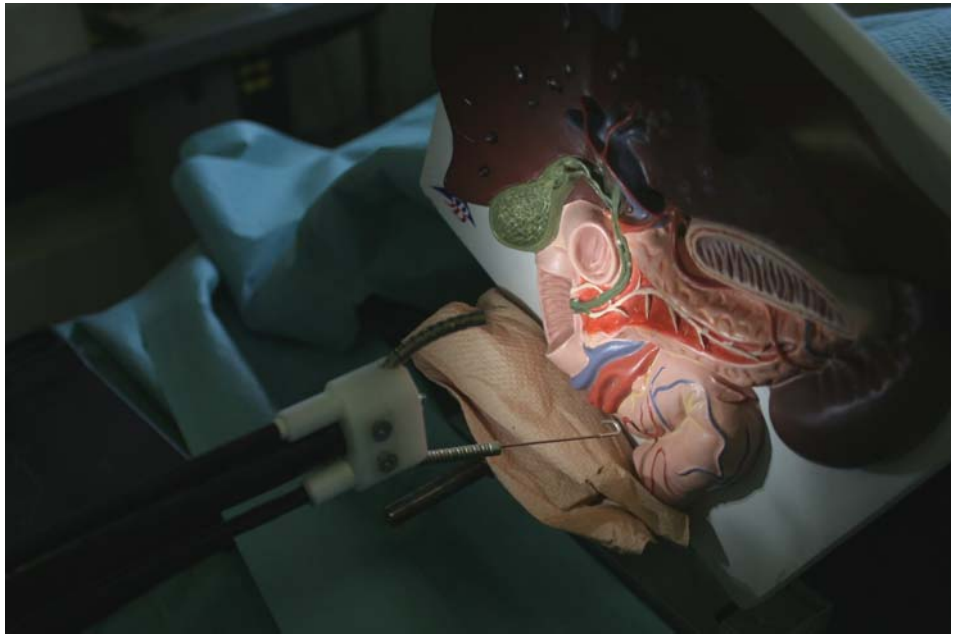
Single user Master Slaves NOTES Robot



LSIIT Robotic team of Michel de Mathelin, IRCAD/ Strasbourg university

External Motors : Endoscope Robot

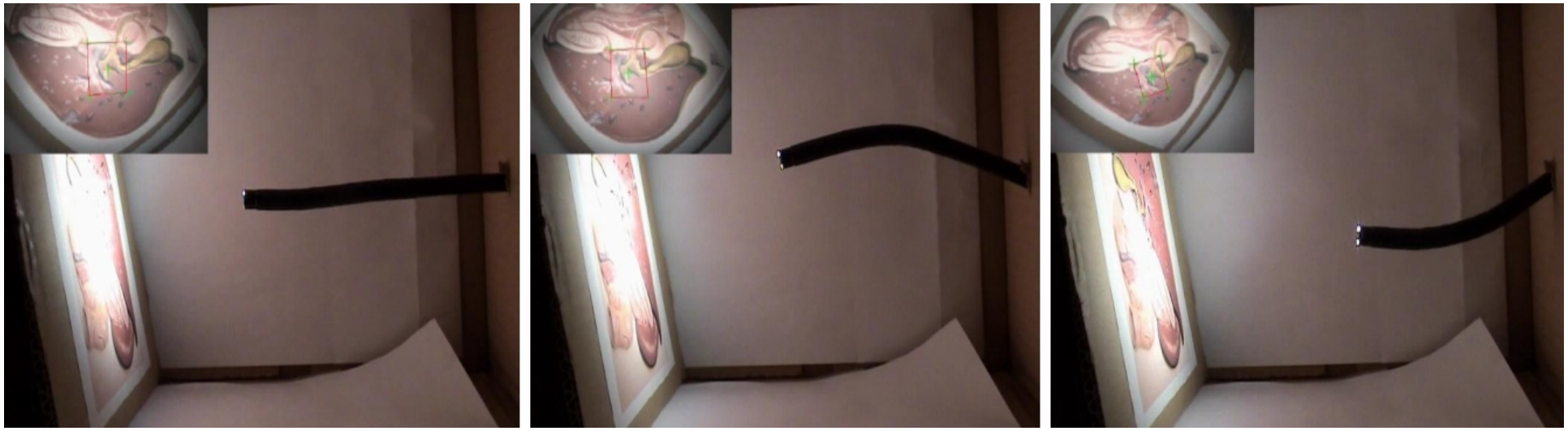
Single user Master Slaves NOTES Robot



LSIIT Robotic team of Michel de Mathelin, IRCAD/ Strasbourg university

Robotics : Automatic instrument control

Automatic Flexible endoscope control



LSIIT Robotic team of Michel de Mathelin, IRCAD/ Strasbourg university

Robotics : Automatic instrument control

WITHOUT Automatic Flexible endoscope control

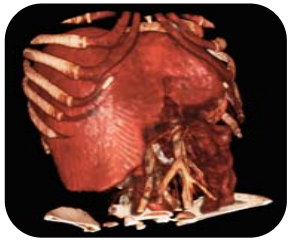
LSIIT Robotic team of Michel de Mathelin, IRCAD/ Strasbourg university

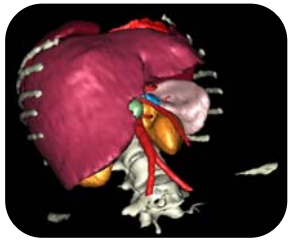
Robotics : Automatic instrument control

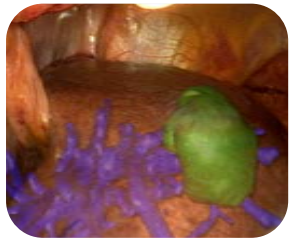
WITH Automatic Flexible endoscope control

LSIIT Robotic team of Michel de Mathelin, IRCAD/ Strasbourg university

Conclusion







Future Vision of Surgery...