

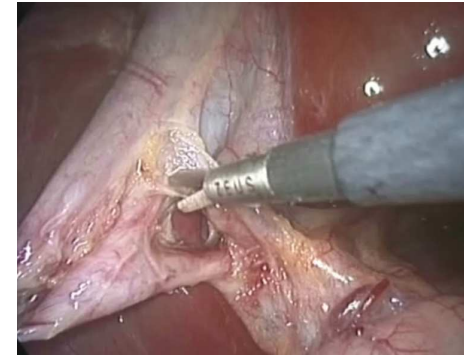
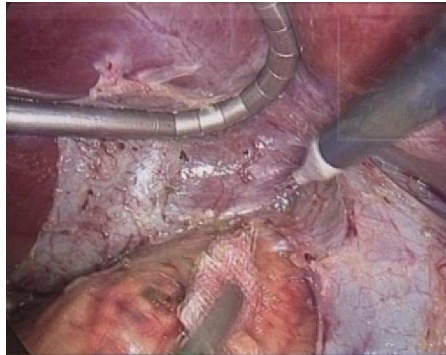
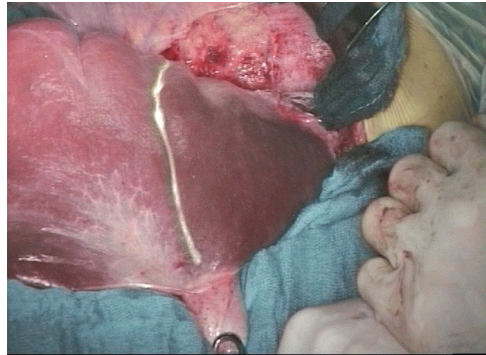
# Information age & surgery : from pre-operative simulation to remote surgery



**Pr. Luc Soler, Pr. Jacques Marescaux**

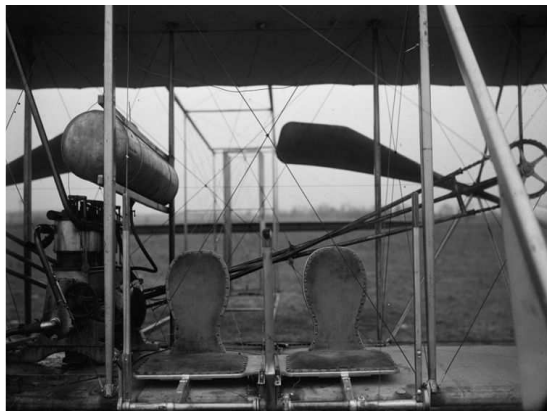
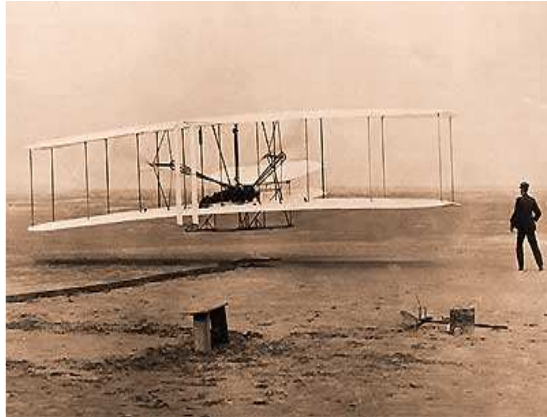
# 20<sup>th</sup> century Surgical Evolution

Open → Laparoscopy → Robotics



*Evolution of surgery*

# Another XX<sup>th</sup> century revolution



***State of surgery today***

# And tomorrow ?...



***What we hope for surgery tomorrow***

# WebSurg : Continuous education

## I. Web site

The screenshot displays the WebSurg website interface as of February 9, 2005. The top navigation bar includes categories such as GENERAL AND DIGESTIVE SURGERY, ENDOCRINE SURGERY, PEDIATRIC SURGERY, THORACIC SURGERY, UROLOGY, GYNECOLOGY, CARDIOVASCULAR SURGERY, and EQUIPMENT SURGERY. The main content area is divided into several sections:

- WebSurg's World Virtual University:** Promotes a brand-new search engine and provides a link to use it.
- Operative technique chapters:** Announces 2 new chapters: "Equipment and 3D vision" and "Transperitoneal laparoscopic radical nephrectomy".
- Discover a new format for Experts' Opinions:** Mentions an advanced operative gynecological surgery course (IRCAD-EITS, June 28-30, 2004).
- 11 New Videos in Laparoscopic Surgery:** Lists various procedures including virtual colonoscopy, gastric band slippage, Nissen procedure, and rectosigmoid resection.
- WebSurg CD-ROMs:** Announces a new CD-ROM for transperitoneal laparoscopic radical nephrectomy (WSNEPHR2).

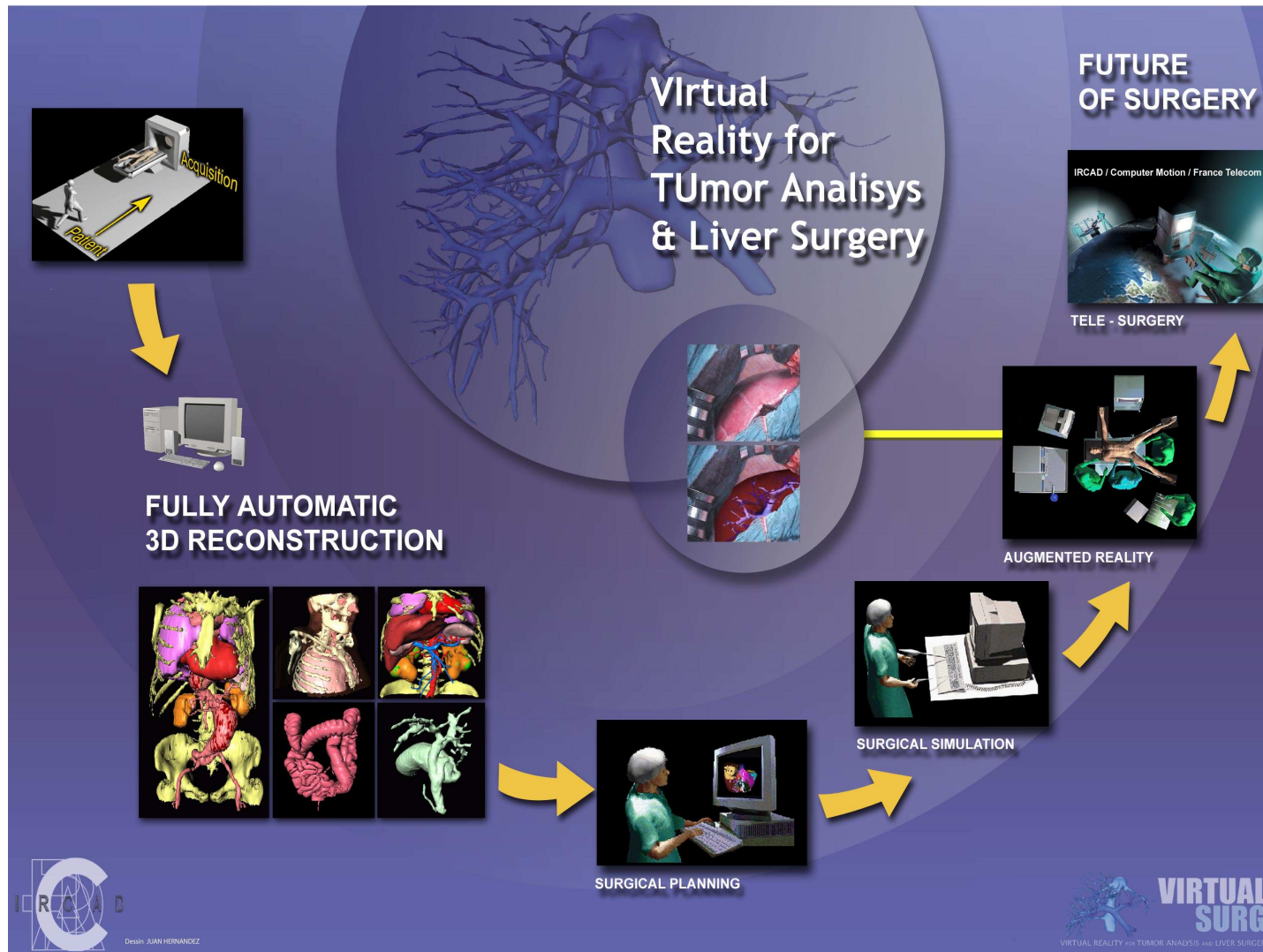
On the right side, there is a "Table of contents" section with a search bar and a "validate" button. Below it is a table listing various surgical topics and their associated content counts:

Organ	Procedure	Count
Adrenal glands	Left adrenalectomy	3 7
	Right adrenalectomy	3 5
Bladder	Laparoscopic bladder diverticulectomy	2
	Burch colposuspension	2 1
Kidney and ureter	Retropertoneoscopic radical nephrectomy	2 1 20
	Transperitoneal nephrectomy	1 10 20
Non-functioning kidney	Extrapertoneal nephrectomy	2 2 27
	Retropertoneoscopic nephrectomy	2 27
Obstructive uropathy	Retropertoneoscopic partial nephrectomy	2 27
	Extrapertoneal cystostomy	2 2 9
Renal insufficiency	Laparoscopic intracapsular pyeloplasty	2 2 9
	Laparoscopic nephrectomy	2 22
Stones	Management of urethriasis	1 6
	Percutaneous nephrostolithotomy	2 6
Pelvis	Genitourinary prolapse	2 8 6
	Prostate	Laparoscopic lymphadenectomy
Cancer	Laparoscopic prostatectomy	2 2 38
	Lymphadenectomy for testicular carcinoma	2 8
Testis		

At the bottom of the page, the URL <http://www.websurg.com> is displayed in large white text.

**Totally FREE !...**

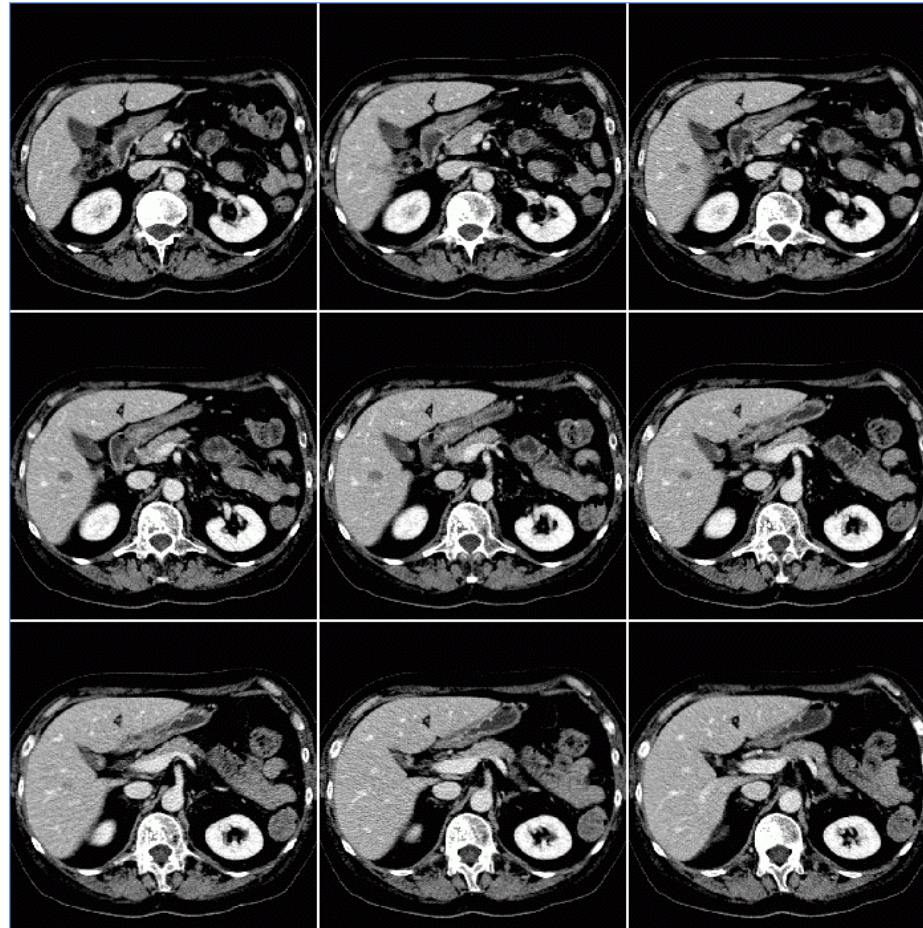
# A global approach



**From Image to Computer assisted Surgery**

# First Step : 3D Modeling of patient

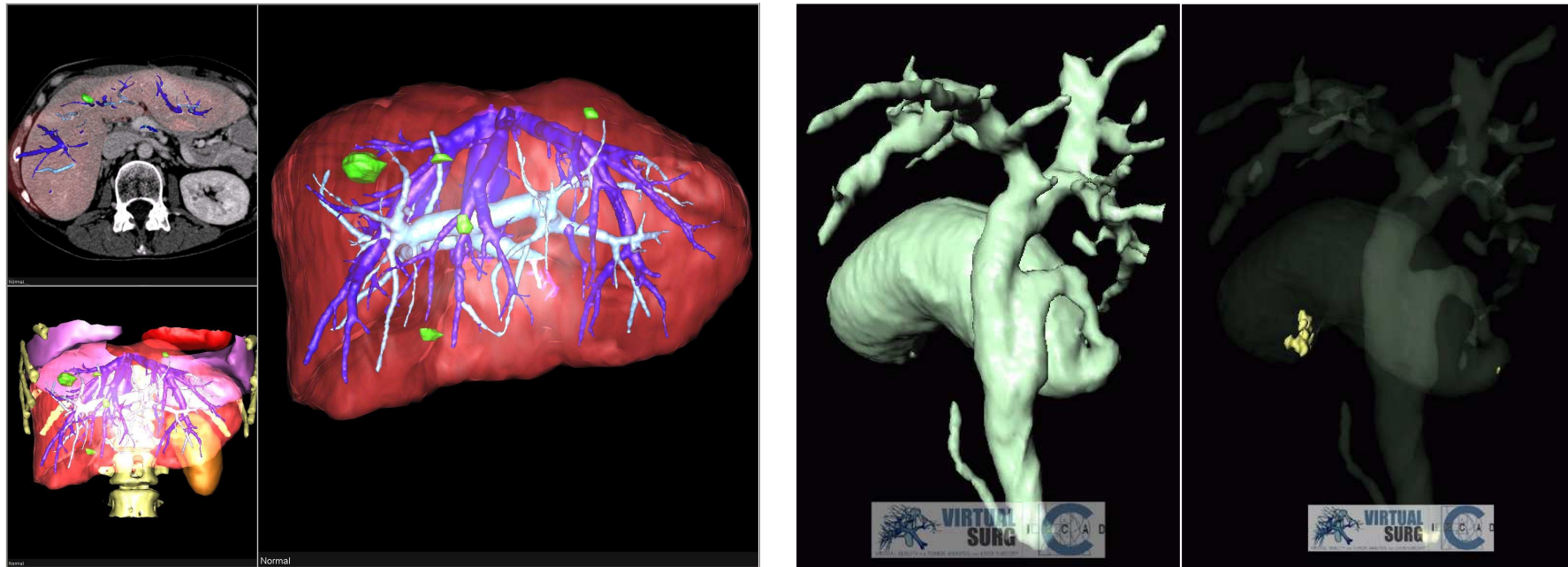
## From CT-scan or MRI of a patient



# First Step : 3D Modeling of patient

Automated delineation (15mn)

*Liver area, colon, biliary tract, adrenal...*



*from CT-Scan*

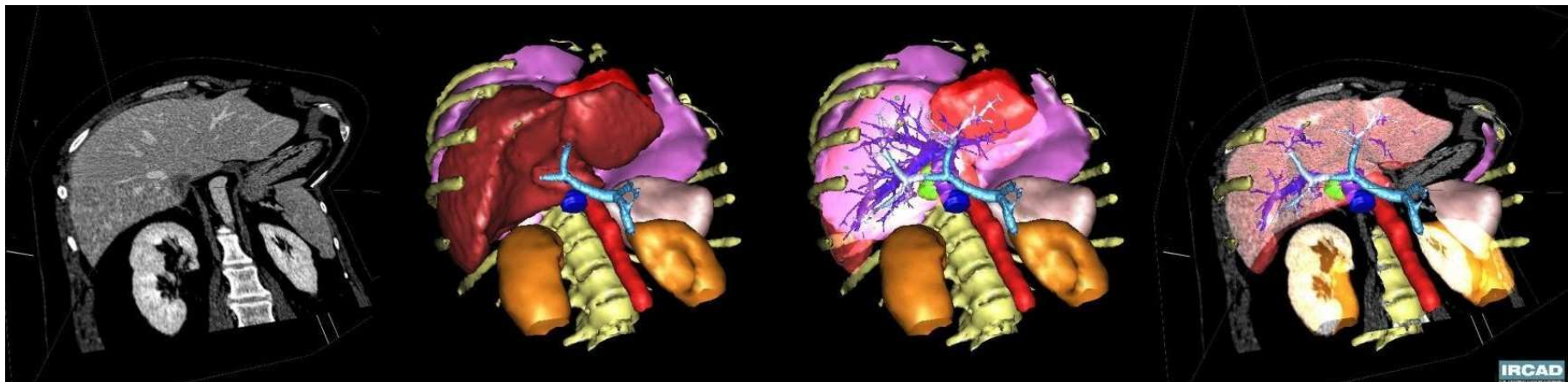
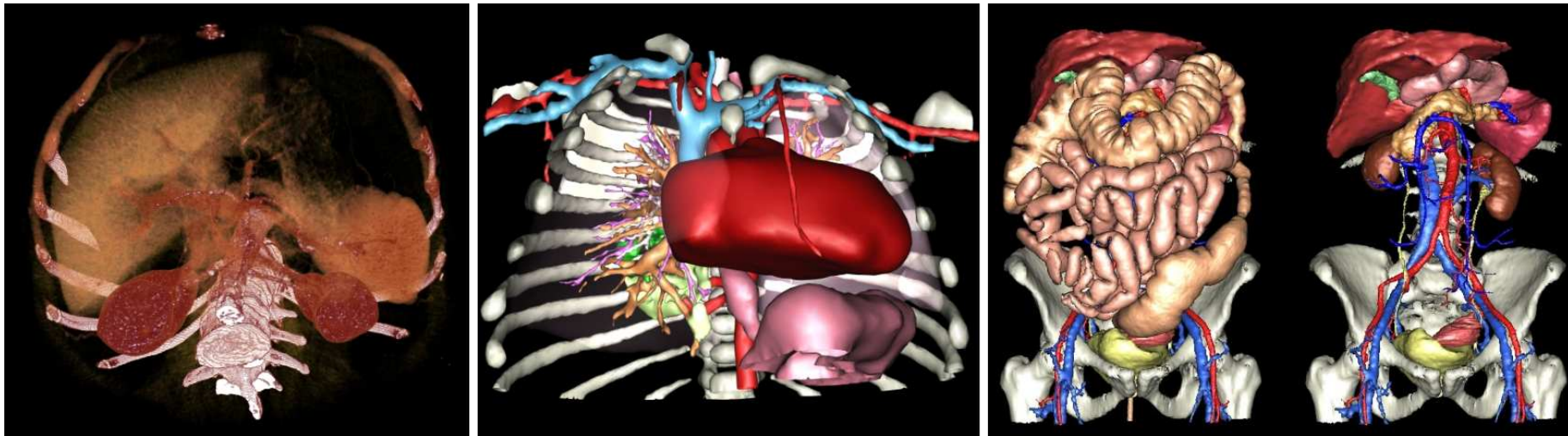
*or*

*from MRI*

*realized with 3D VPM ©ircad 2007*

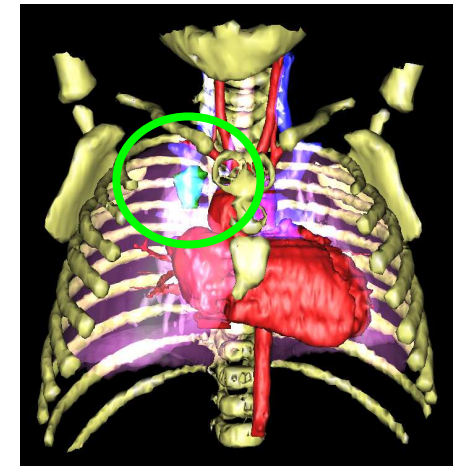
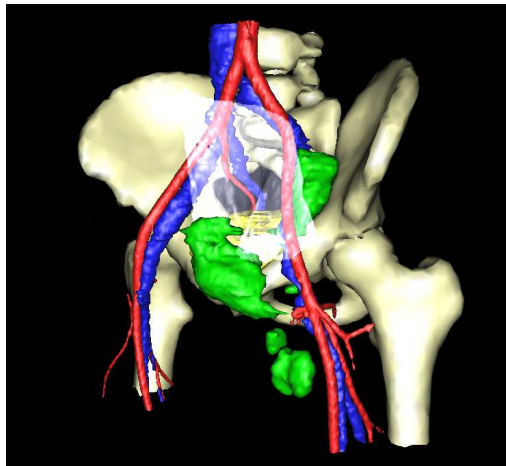
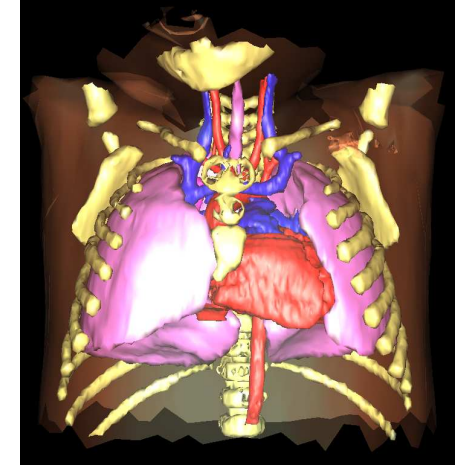
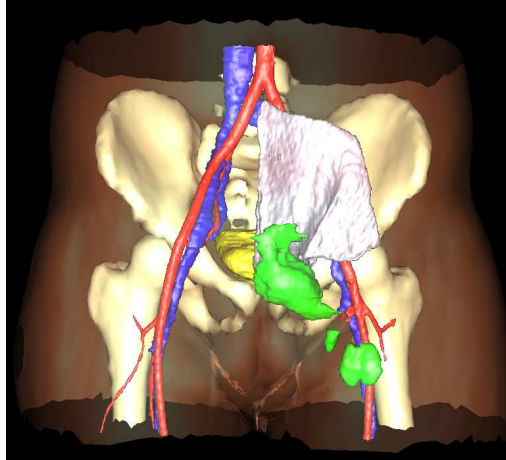
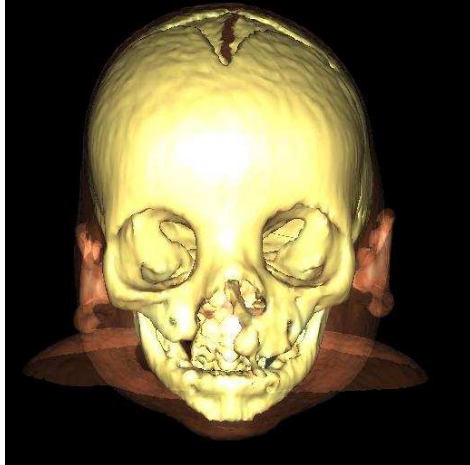


# First Step : 3D Modeling of patient



*realized with 3D VPM ©ircad 2007*

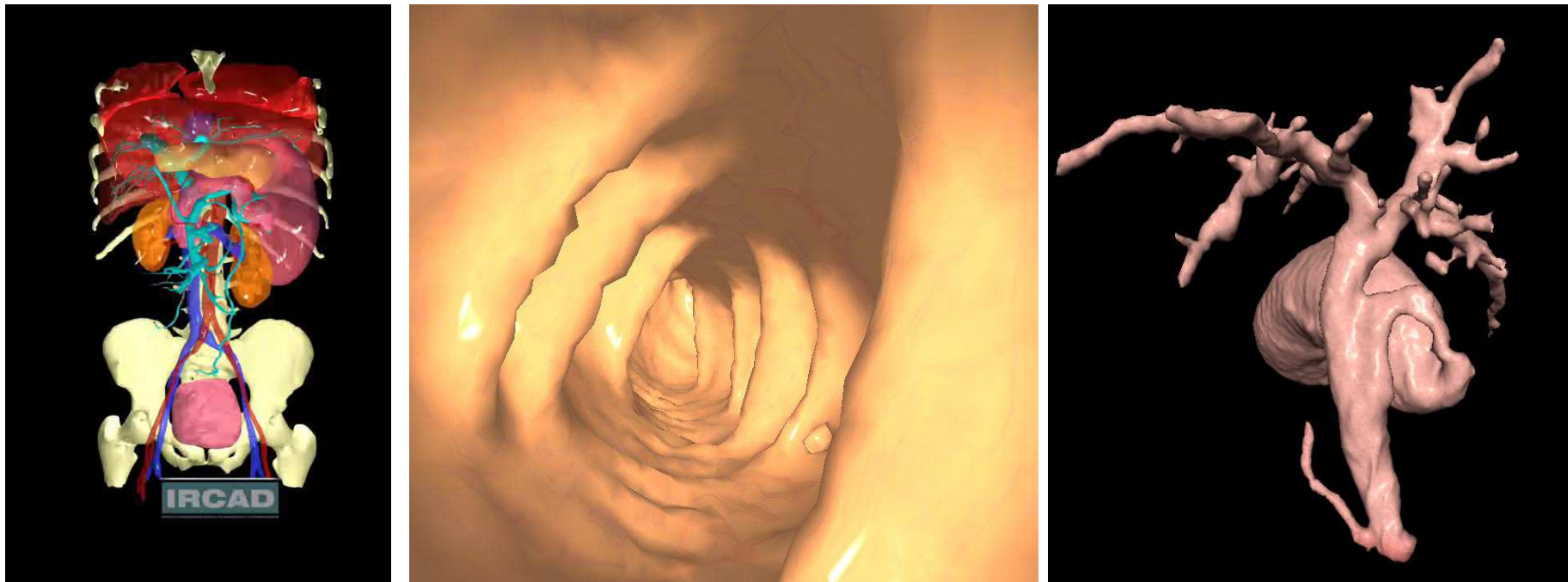
# First Step : 3D Modeling of patient



*Used for paediatric surgery*

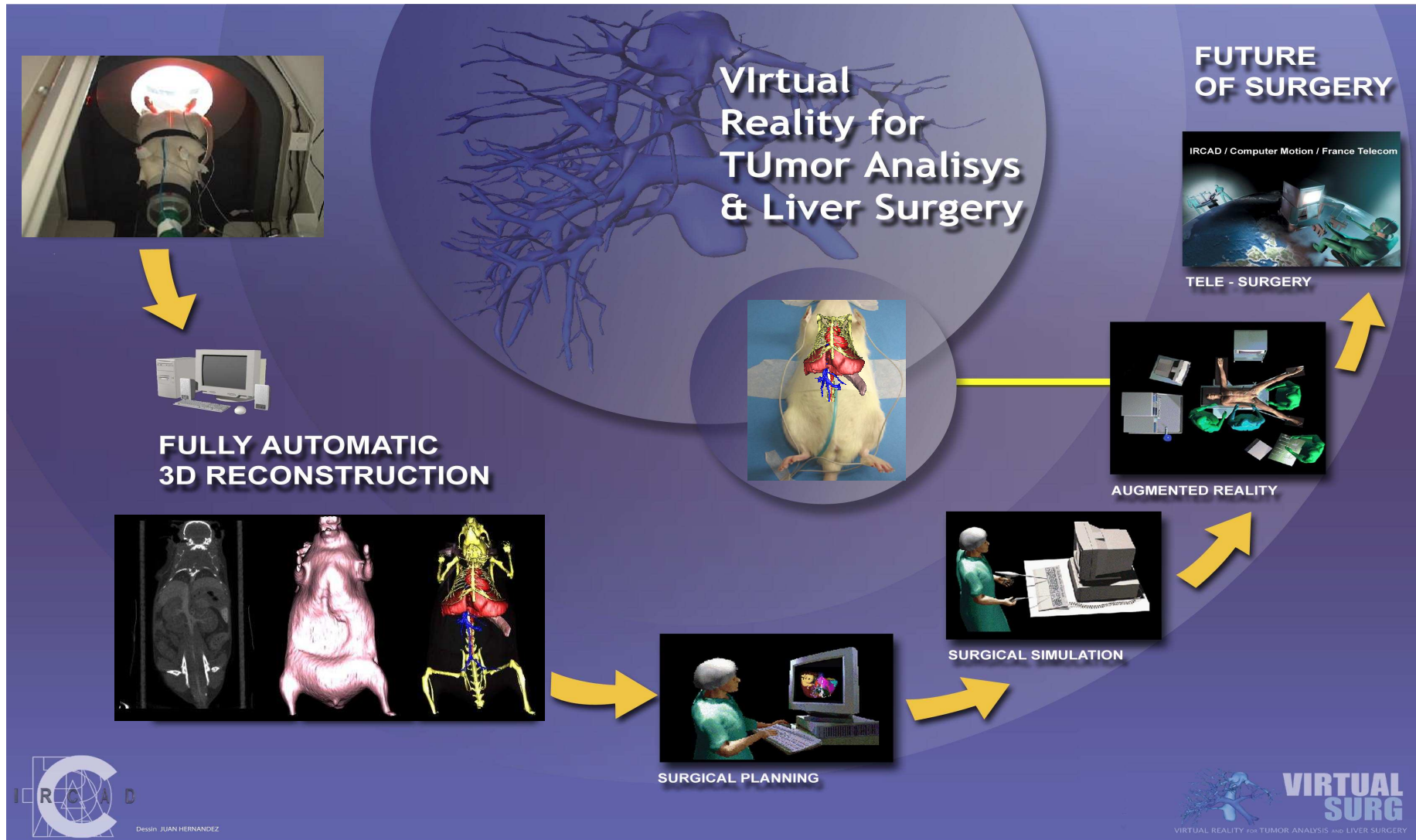
# Surface Rendering visualisation

Can be visualized with any Internet Explorer  
On any kind of computer



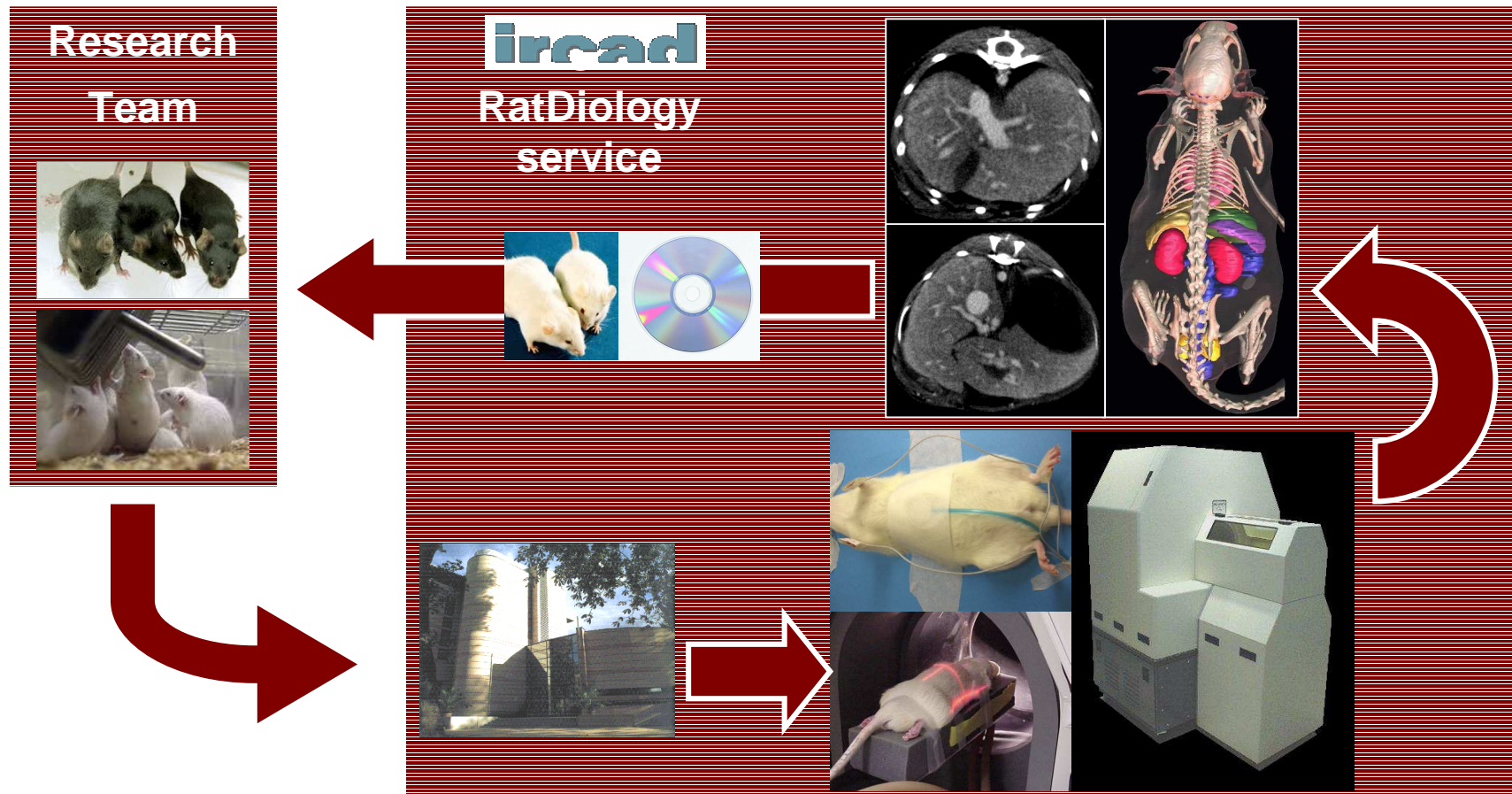
*Texture make image more realistic*

# Preclinical Virtual Reality & Robotics

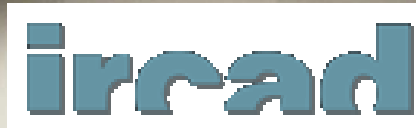


# New tool for fundamental research

Provide a CT-scan imaging service  
for mice and rats including 3D modelling



# IRCAD's Micro CT-scanner

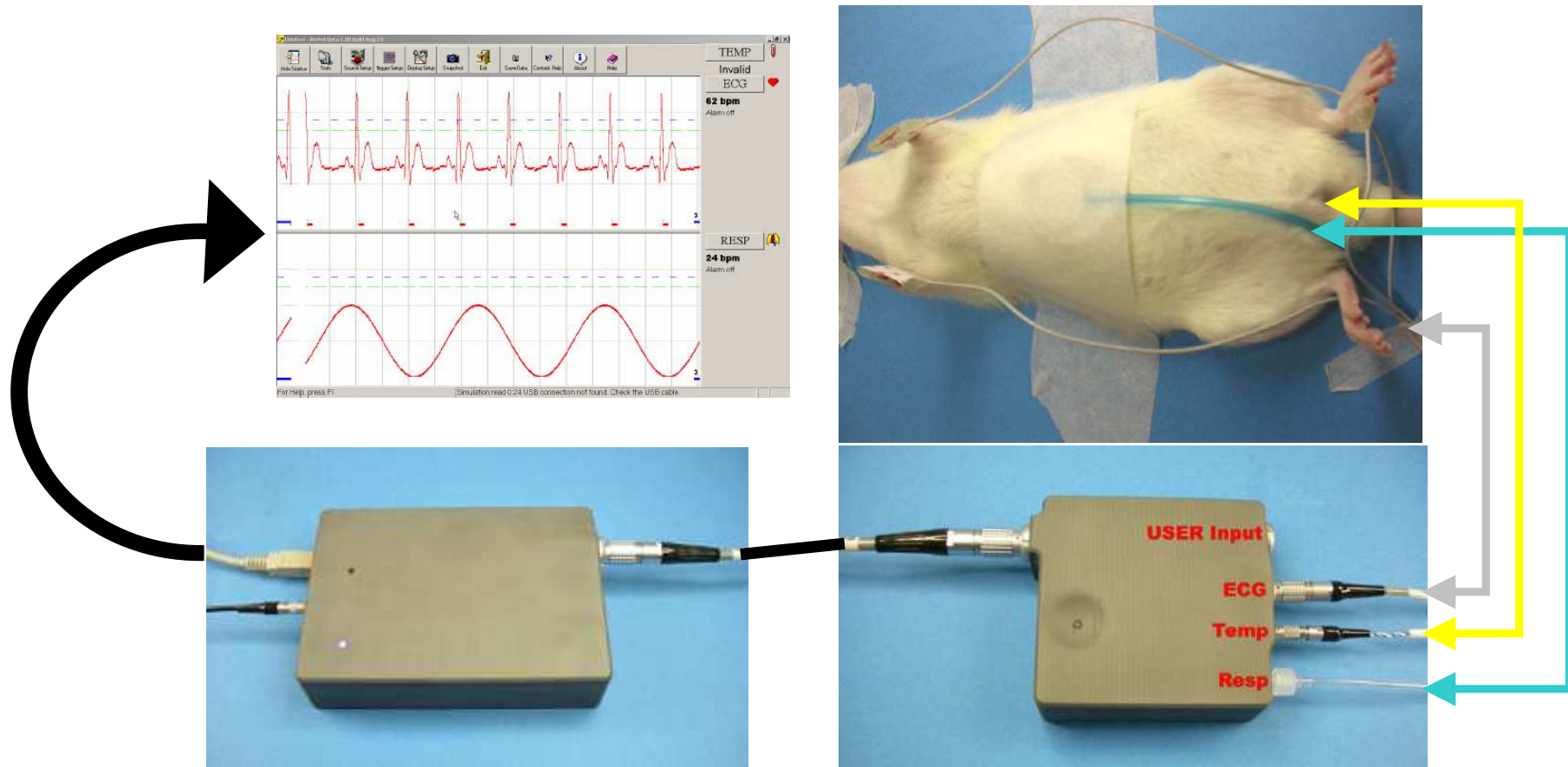


*Région Alsace, Département Bas-Rhin, Ville de Strasbourg,  
Ligne Nationale contre le cancer*

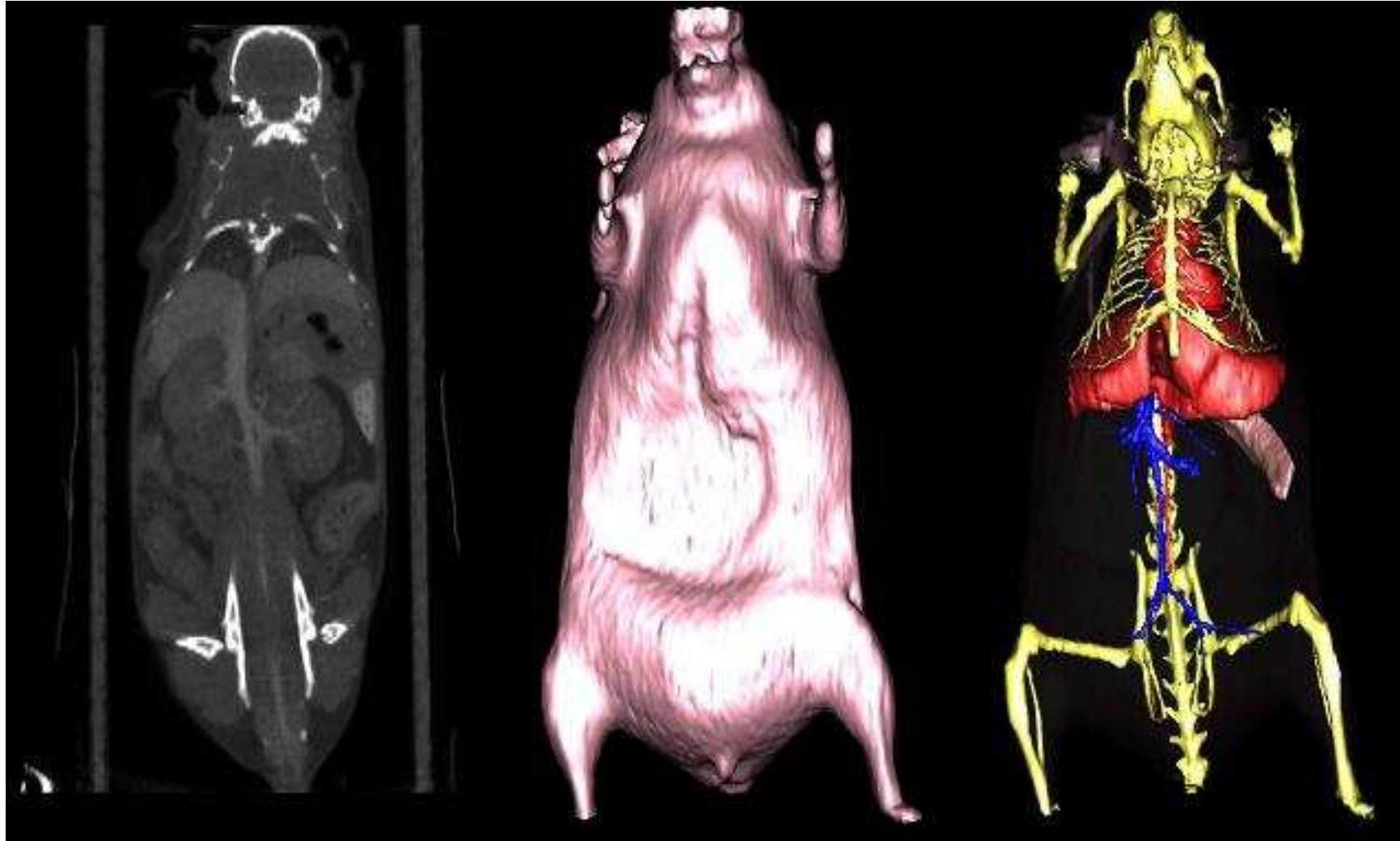


# In vivo Micro scanner X

## Automatic Synchronisation



# 3D modelling of small animals

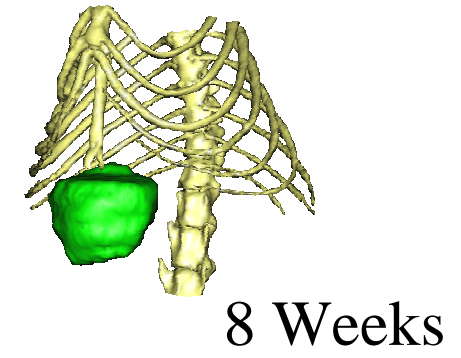
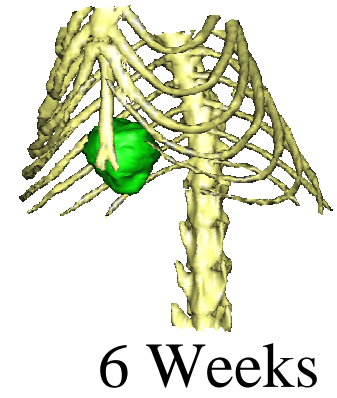
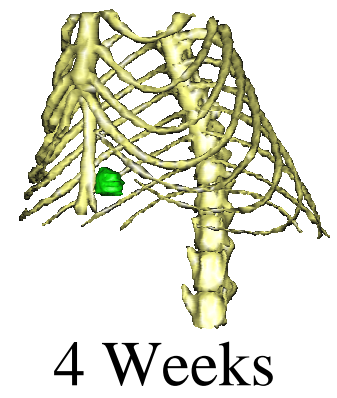
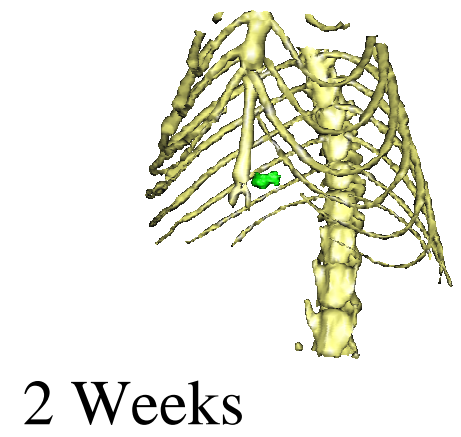
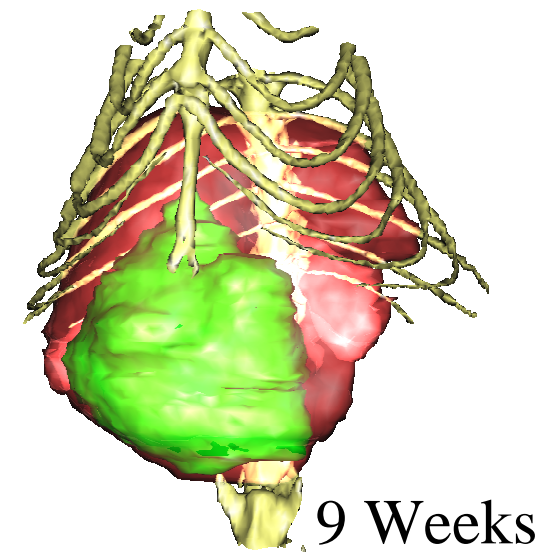
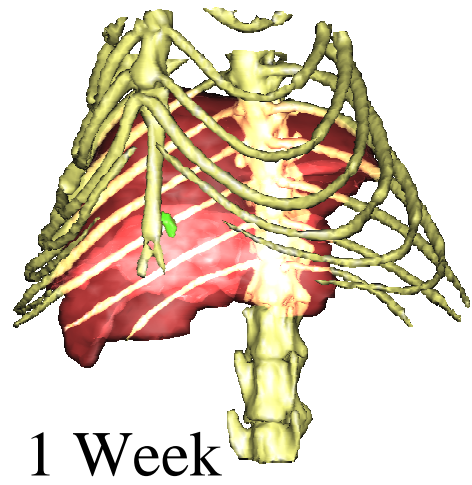


***Intravenous Fenestra LC + Fenestra VC***

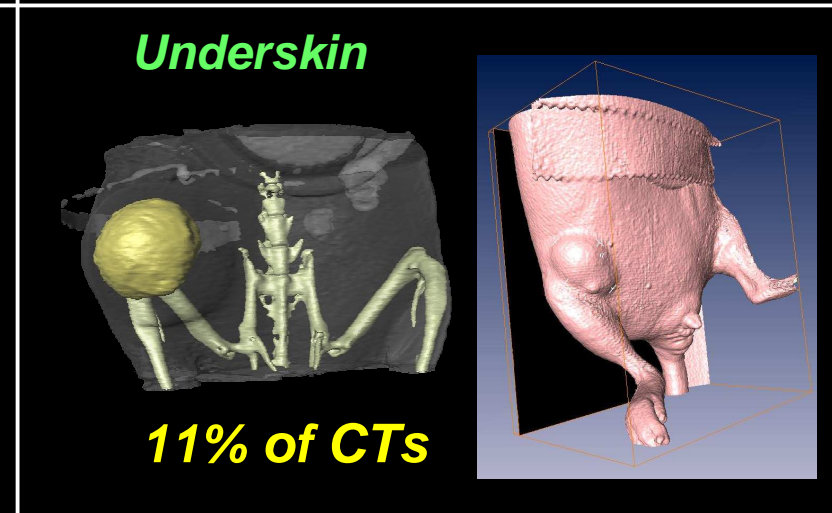
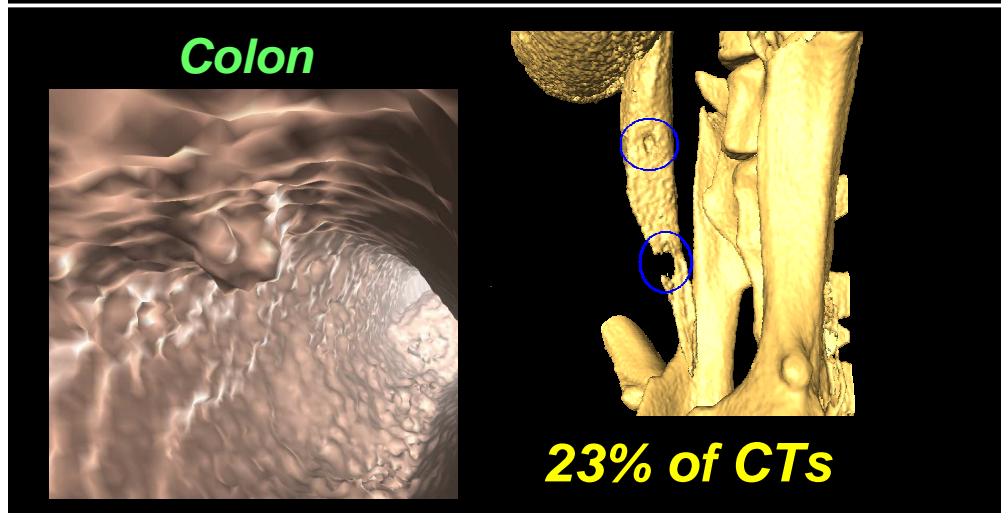
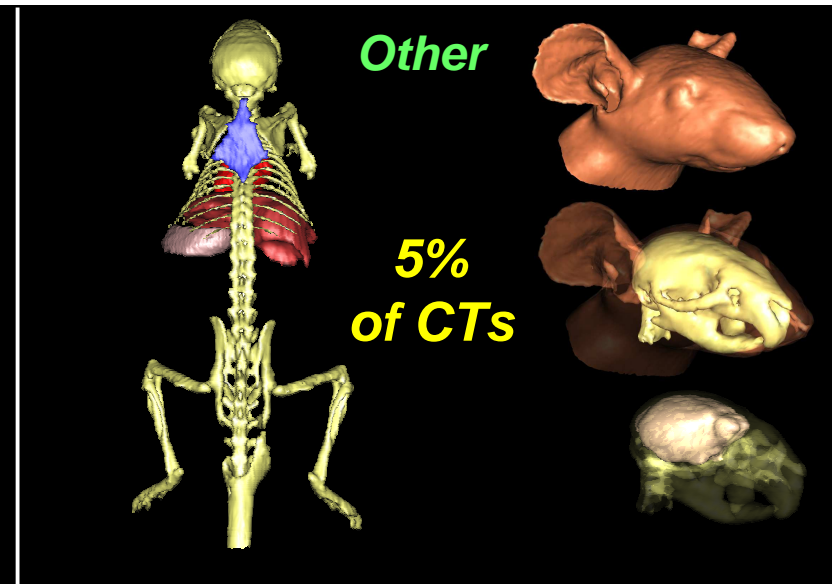
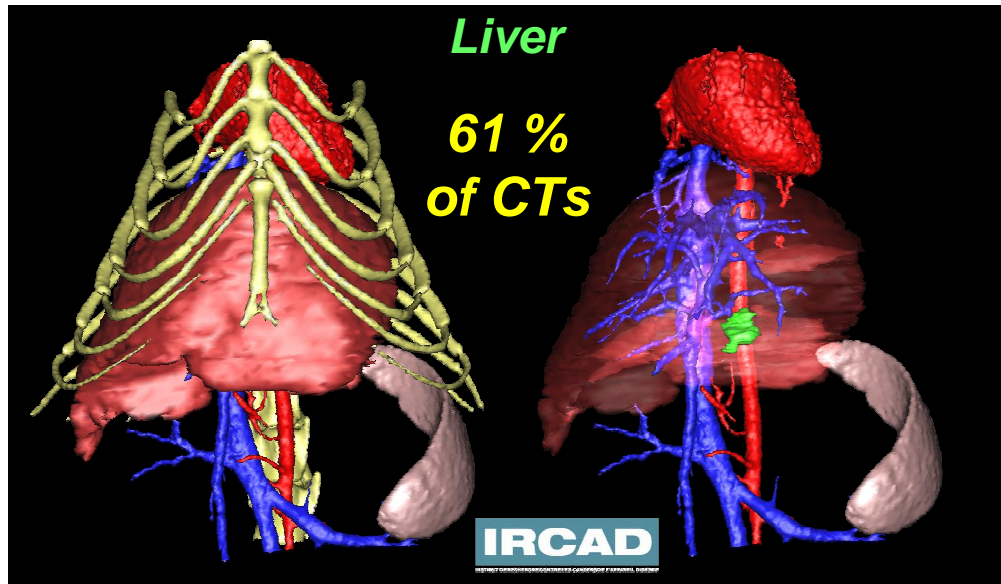


# 4D Comparison

## Liver tumor evolution

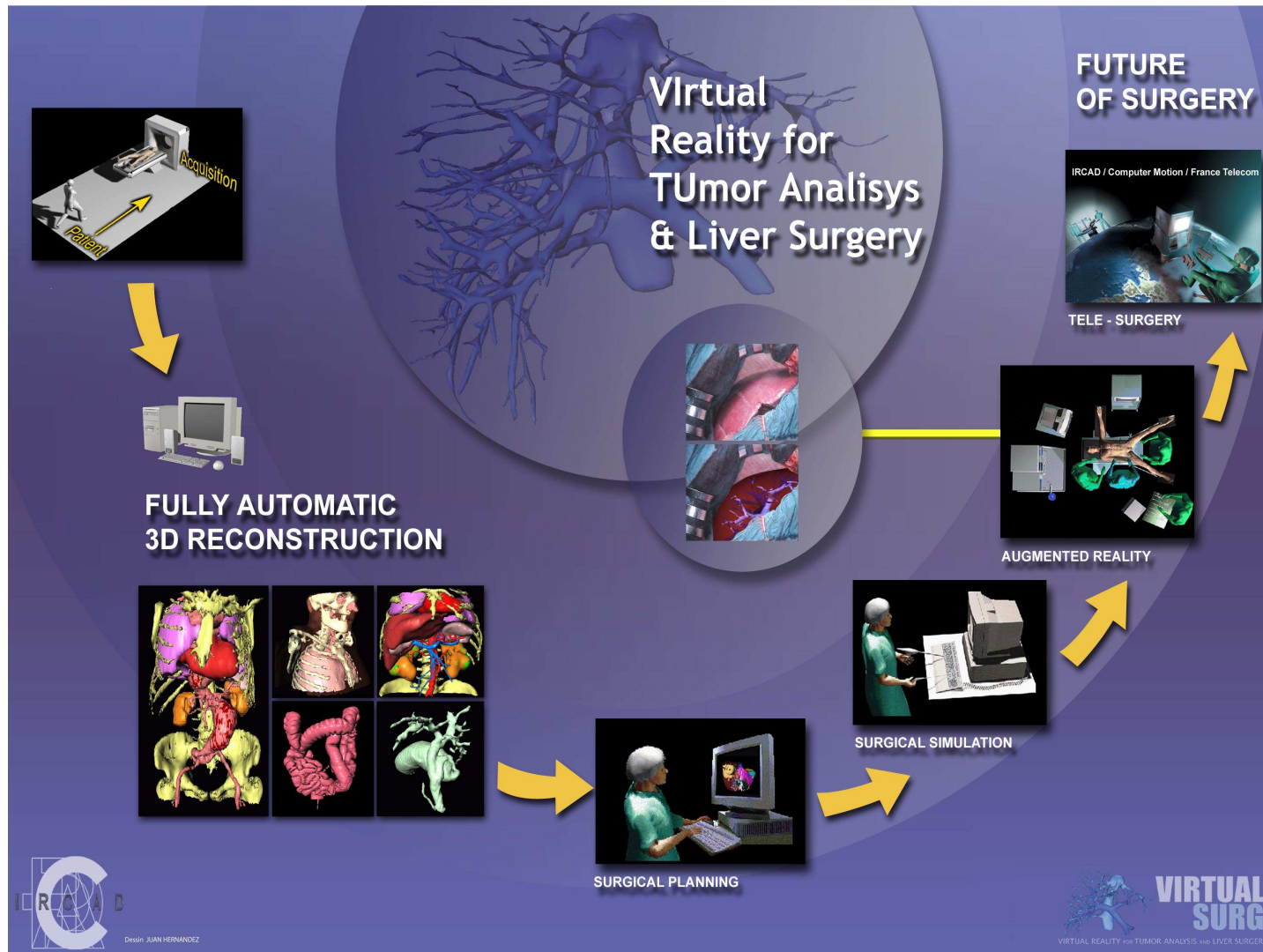


# Ratdiology Project



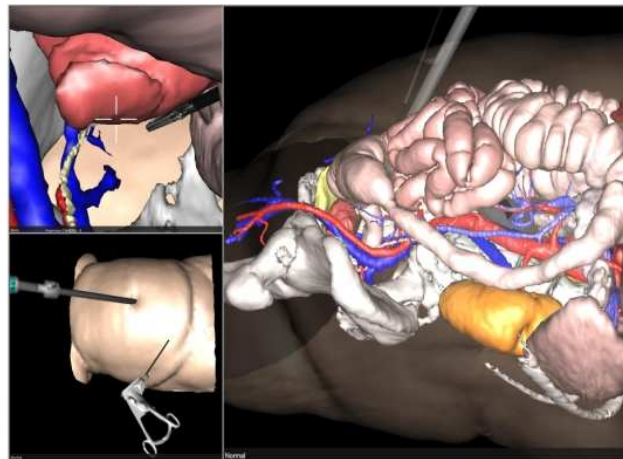
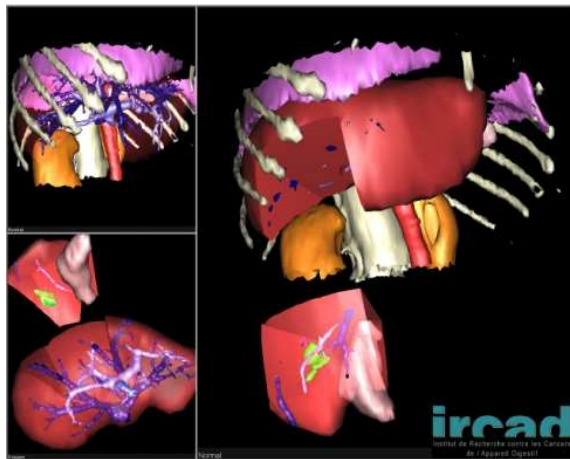
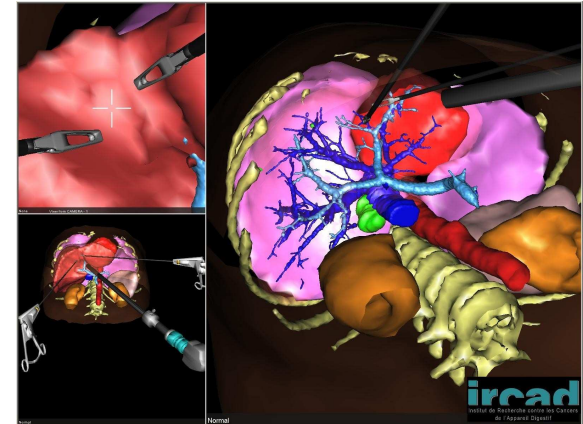
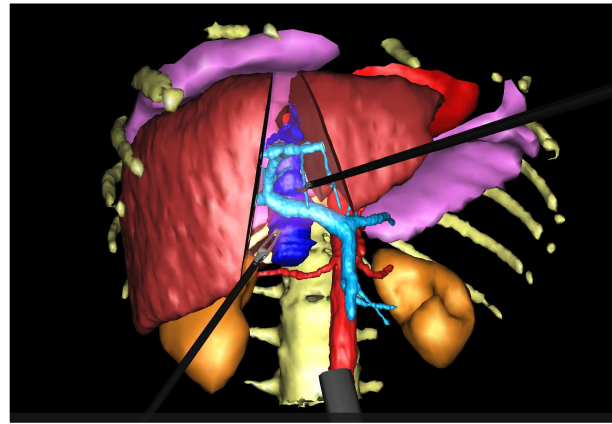
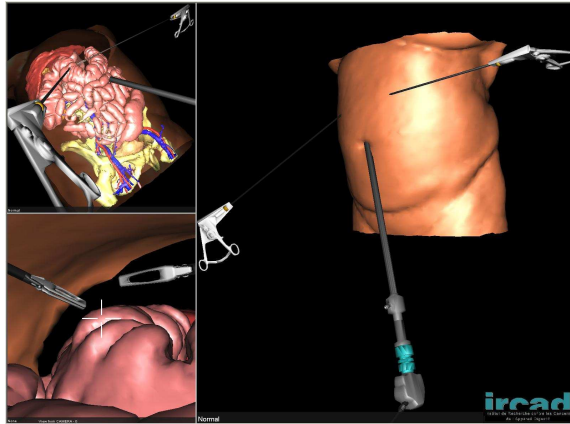
**2005 : 501 CT / 2006 : >700 CT**

# Surgical Planning

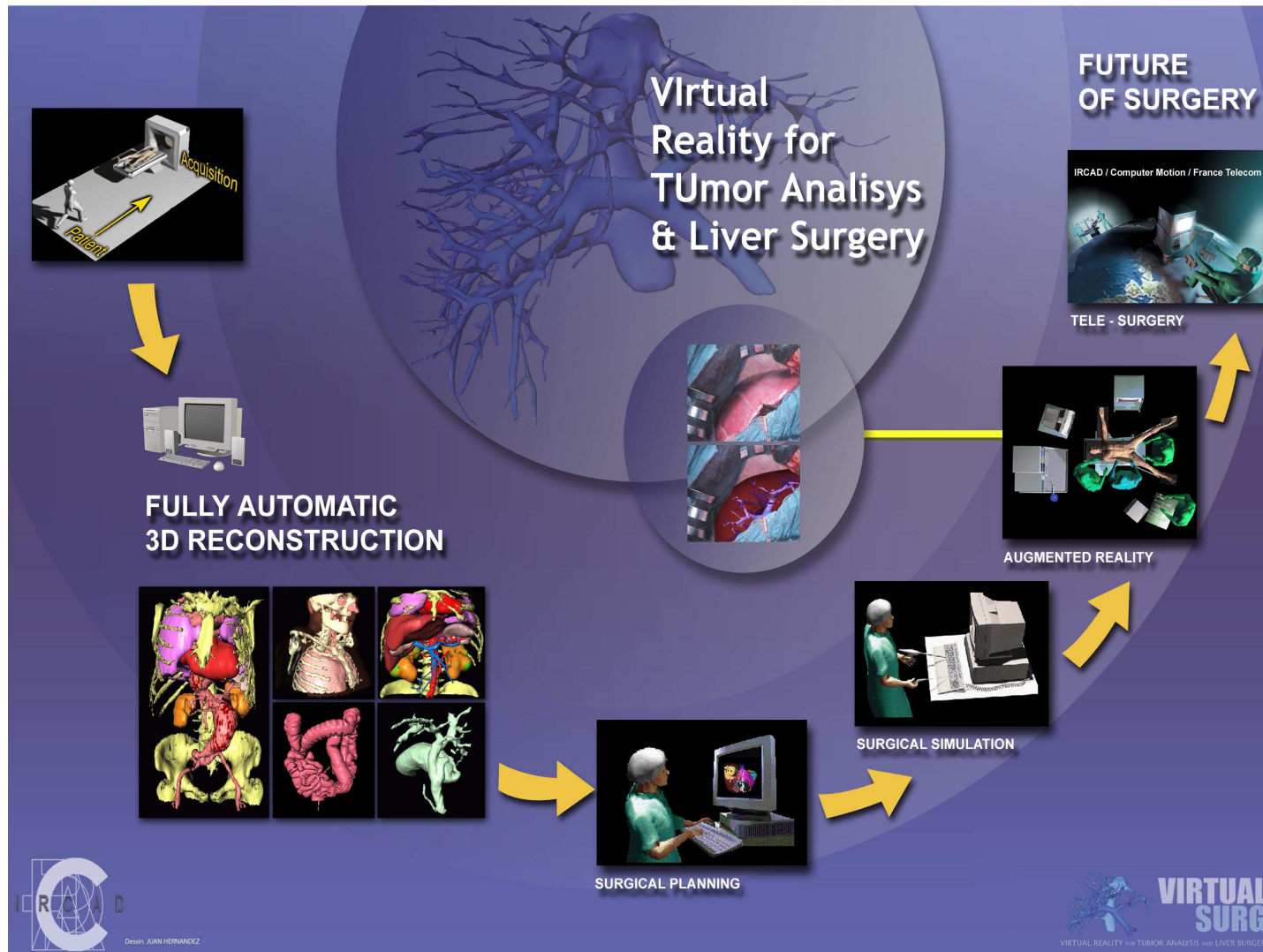


# Second step : Surgical planning

## 3D VSP ©ircad 2002



# Third Step : Surgical Simulation



# Current laparoscopic simulators

©*Surgical Science*

©*Simbionix*

©*SimSurgery*

- Realistic rendering
- Large set of possible training (suture, clip applying, etc...)
- Automated evaluation

**Current laparoscopic simulators**

**BUT : based on non real patient**

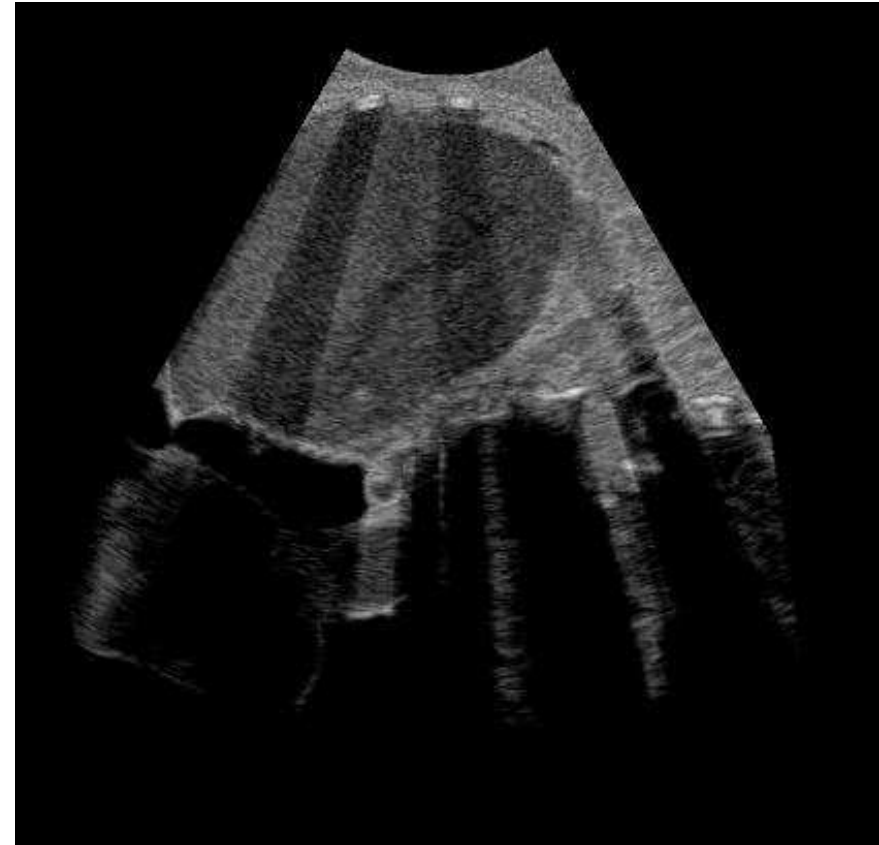
**→ limited database**

***Objective :***

Develop pre-operative simulator  
allowing a real preoperative training  
on virtual copy of patient

# Third Step : Surgical Simulation

## Ultrasonographic Simulator



**From CT-scan of the patient**



# Third Step : Surgical Simulation

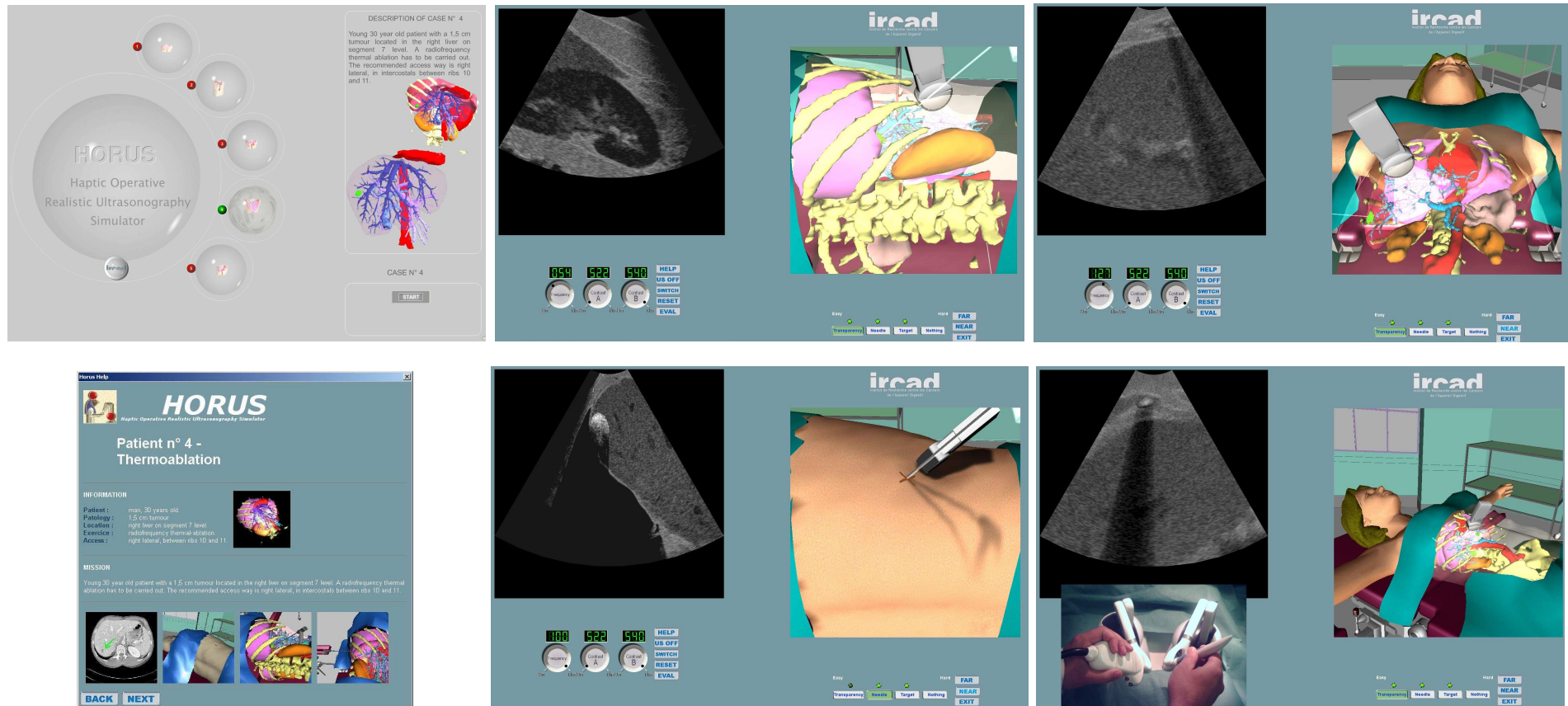
## Fully Realistic Rendering



Where is the real ?

# Third Step : Surgical Simulation

## ultrasonographic percutaneous needle insertion Simulator



**HORUS ©ircad 2005**

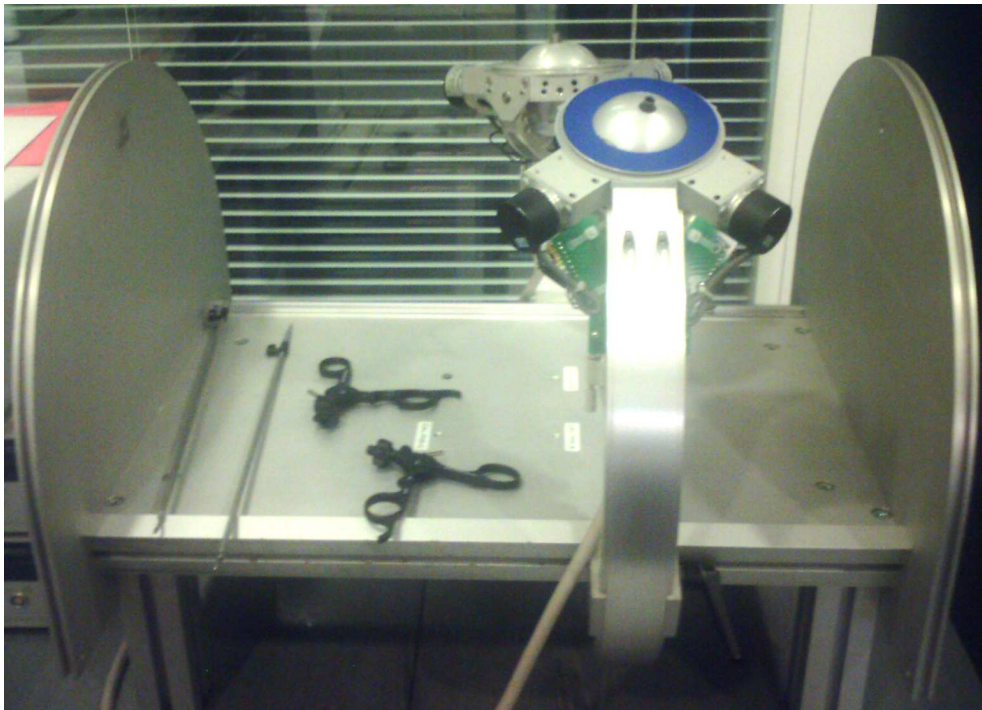
# Third Step : Surgical Simulation

## Real-time Force Feed-Back simulation



# Third Step : Surgical Simulation

Develop a Force Feed-Back simulator  
using the Karl Storz FFB system



*Eurêka “ODYSSEUS” Project*

**STORZ**  
KARL STORZ – ENDOSKOPE

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

# Third Step : Surgical Simulation

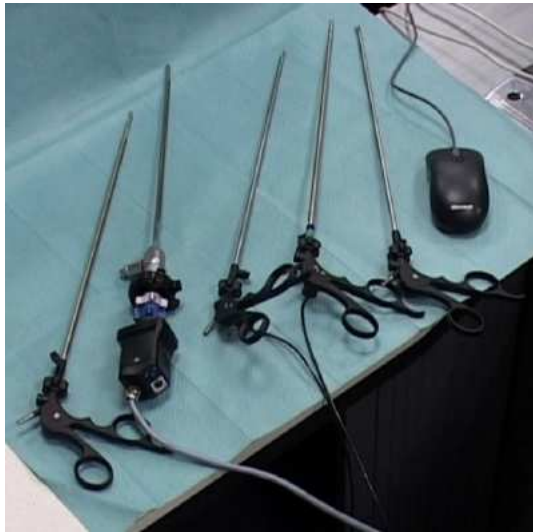


**ULIS ©ircad 2007**

**STORZ**  
KARL STORZ — ENDOSKOPE

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

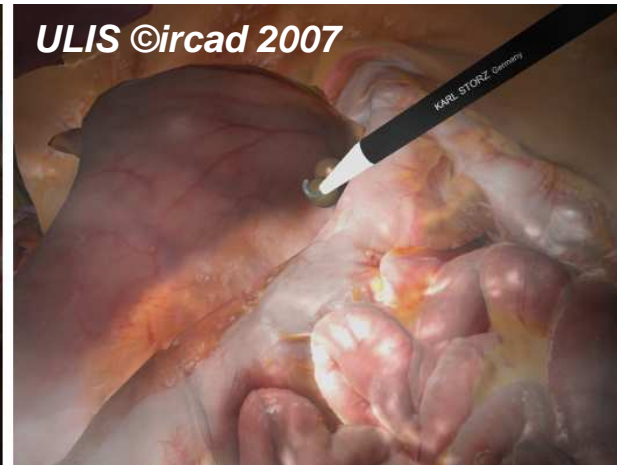
# Third Step : Surgical Simulation



ULIS ©ircad 2007



ULIS ©ircad 2007



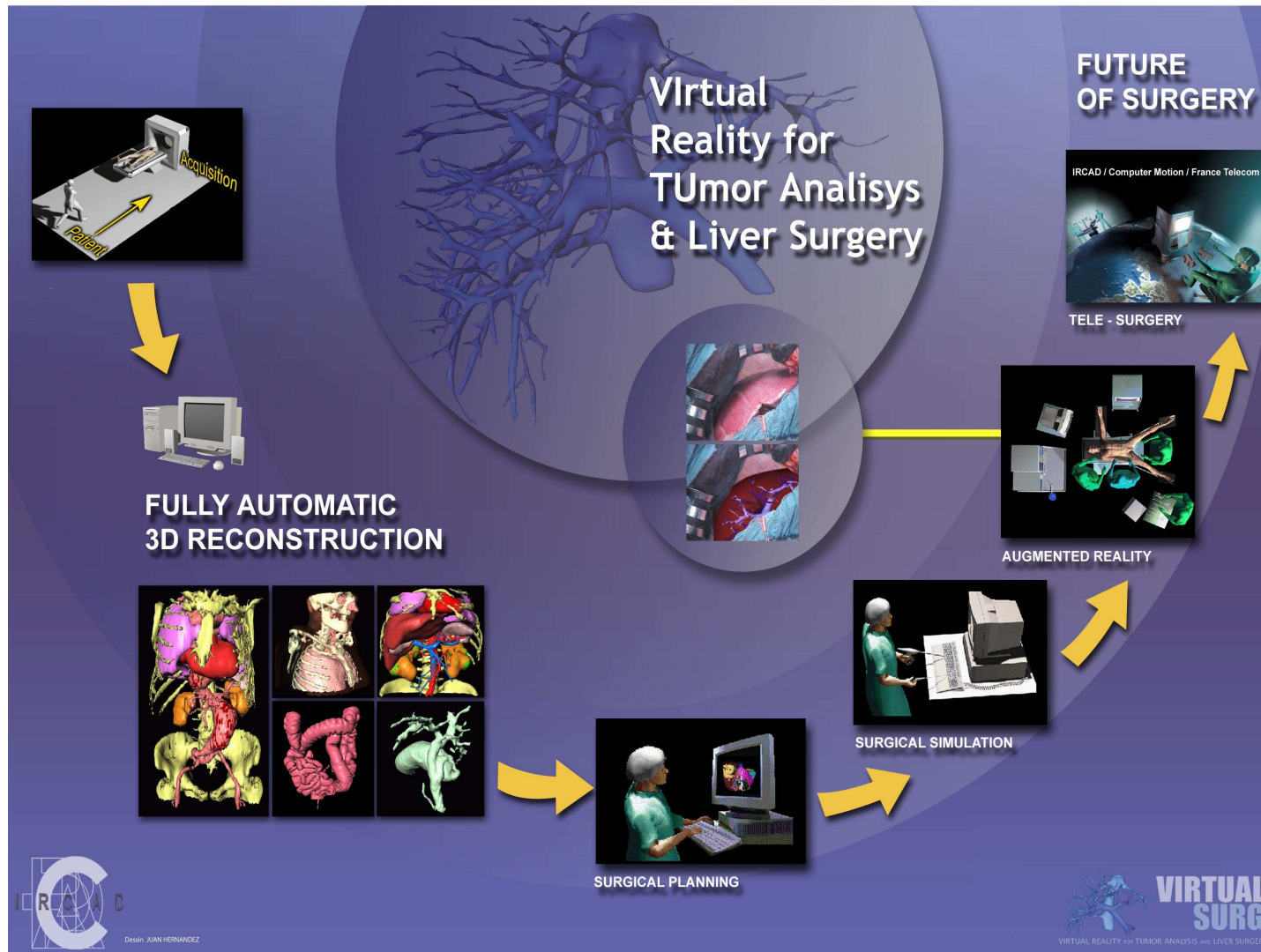
ULIS ©ircad 2007

ULIS ©ircad 2007

**STORZ**  
KARL STORZ — ENDOSKOPE

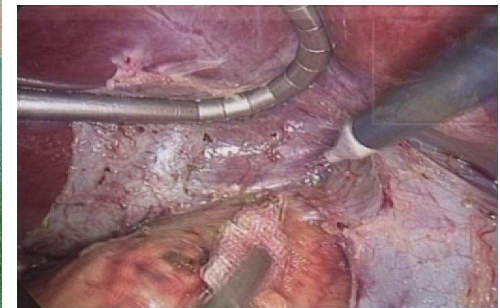
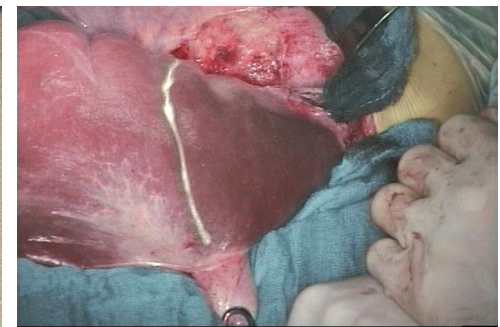
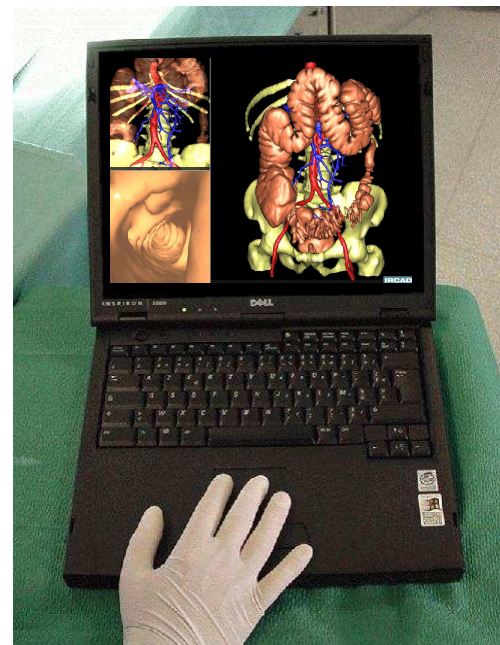
**ircad**  
Institut de Recherche contre les Cancers  
de l'Appareil Digestif

# Intra-operative Use



# Surgical planning software

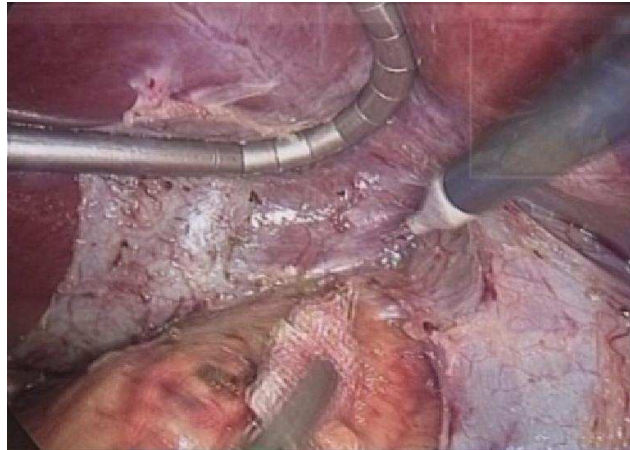
## Open or laparoscopic Surgery





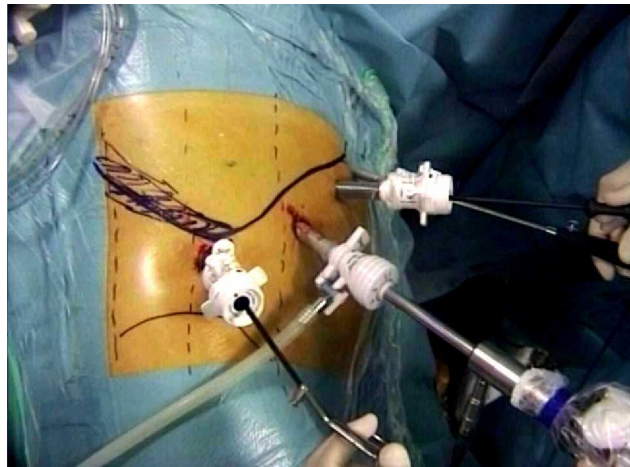
# Forth Step : Intra-operative Use

## Surgical views



**Internal view**

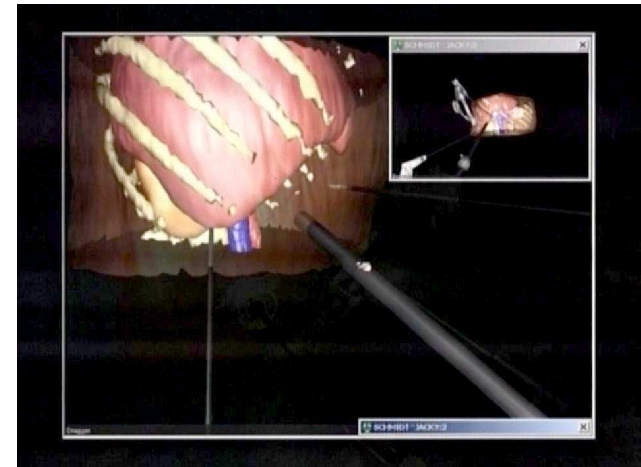
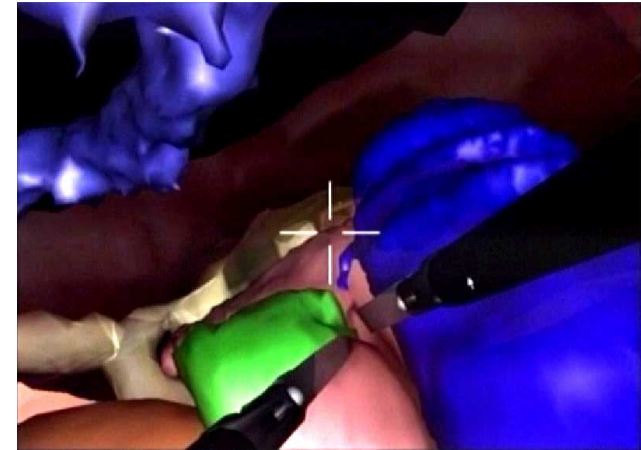
**Real Virtual**



**External view**

**Real Virtual**

## Laptop views

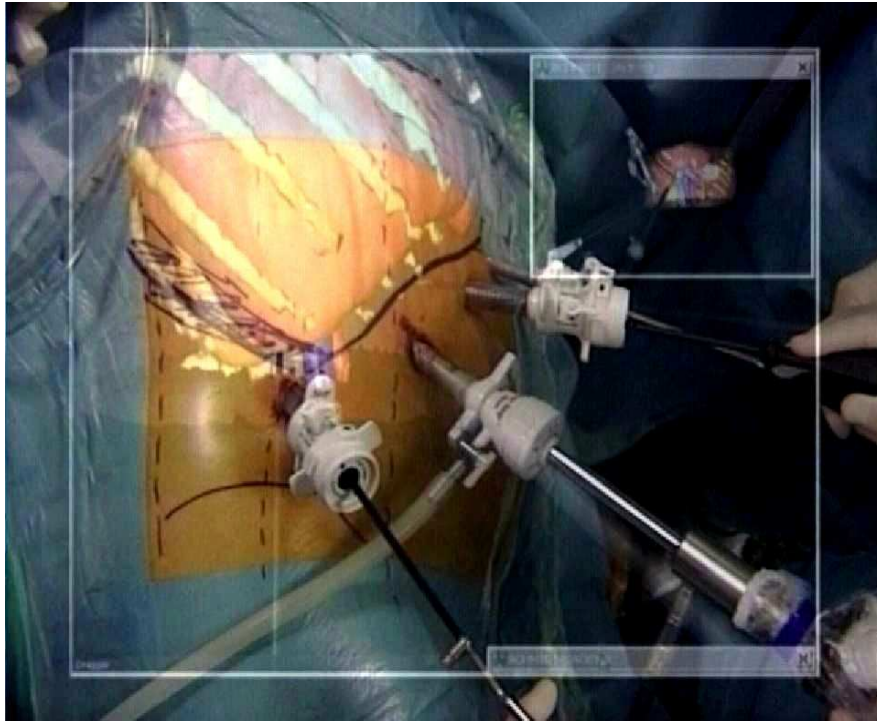


# Forth Step : Intra-operative Use

Optimal use : Fuse real and virtual

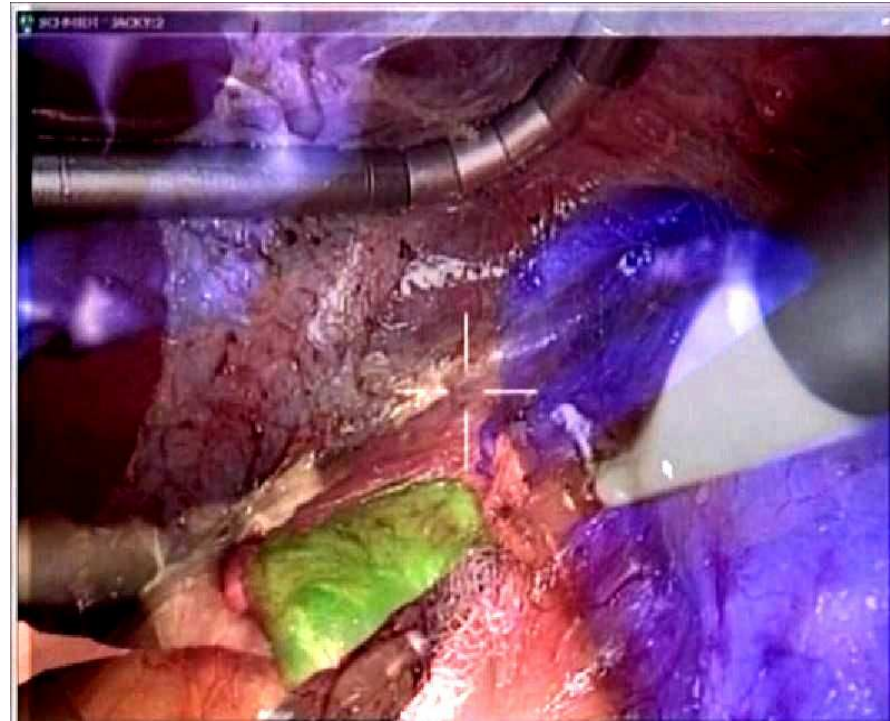
External view

Real + Virtual

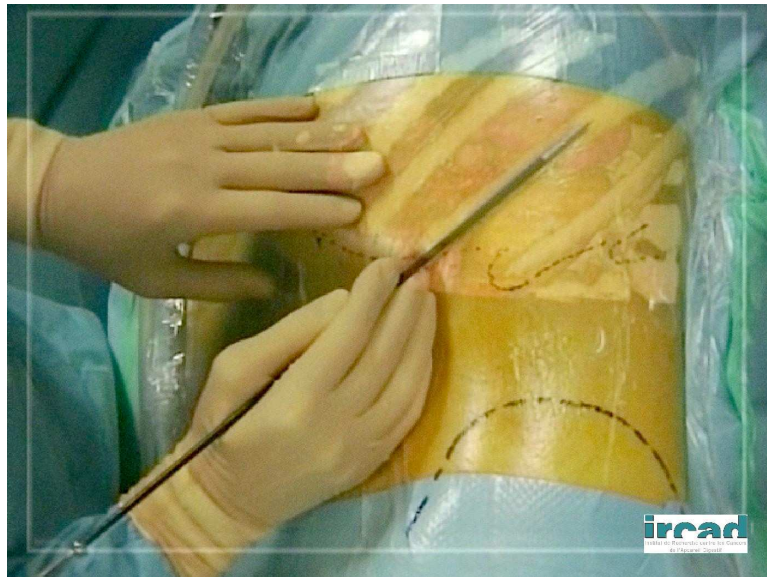
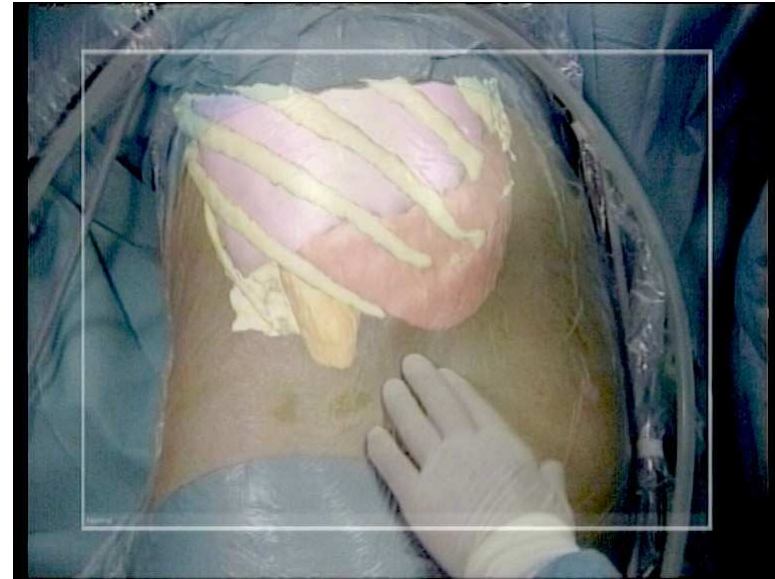


Internal view

Real + Virtual

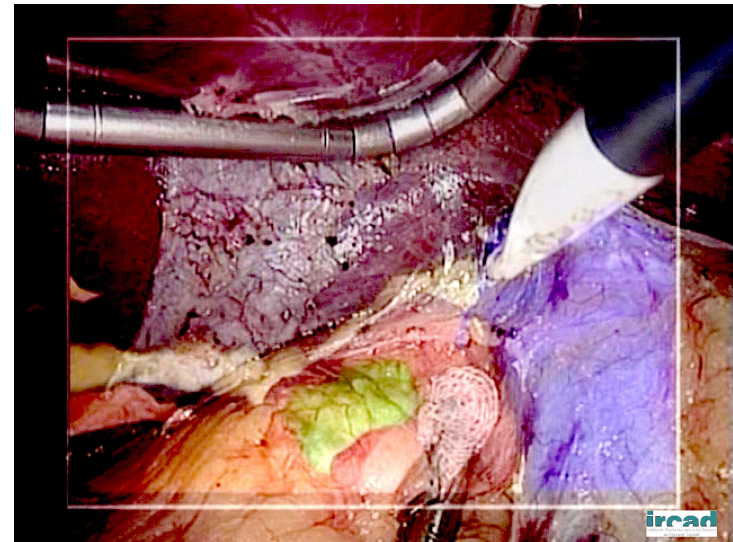
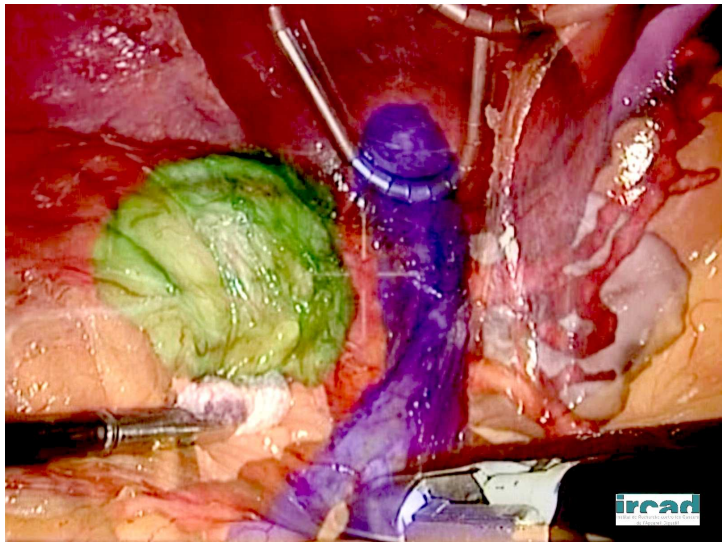
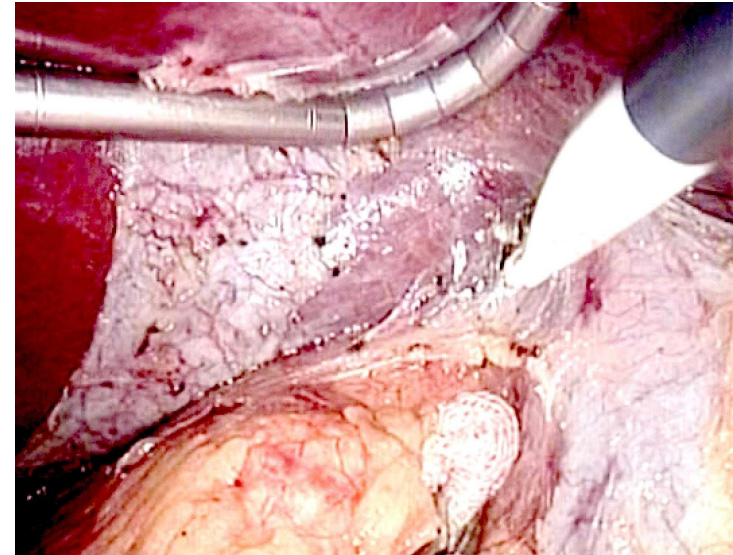
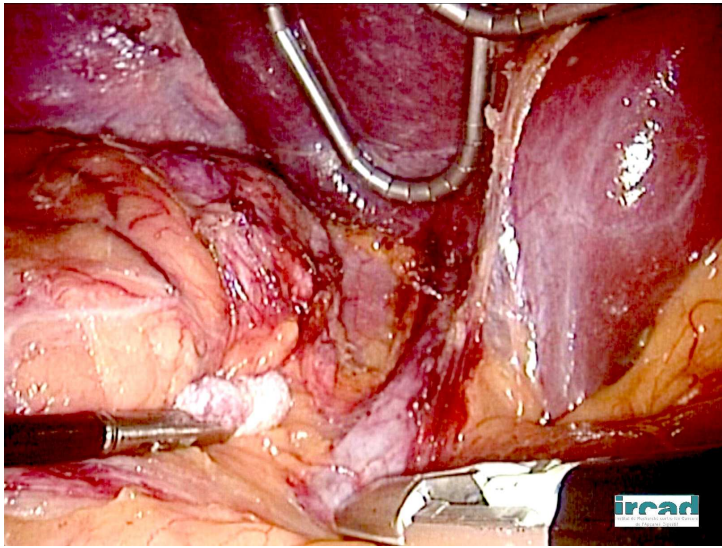


# Interactive Augmented reality



*JAMA November 2004*

# Interactive Augmented reality



*JAMA November 2004*

# **Interactive Augmented reality**

## **LIMITS**

- **Manual Registration of Virtual & Real**
- **Manual Tools Positioning & Tracking**
- **Manual Organs Tracking**
- **Impossible Virtual Organ Deformation**

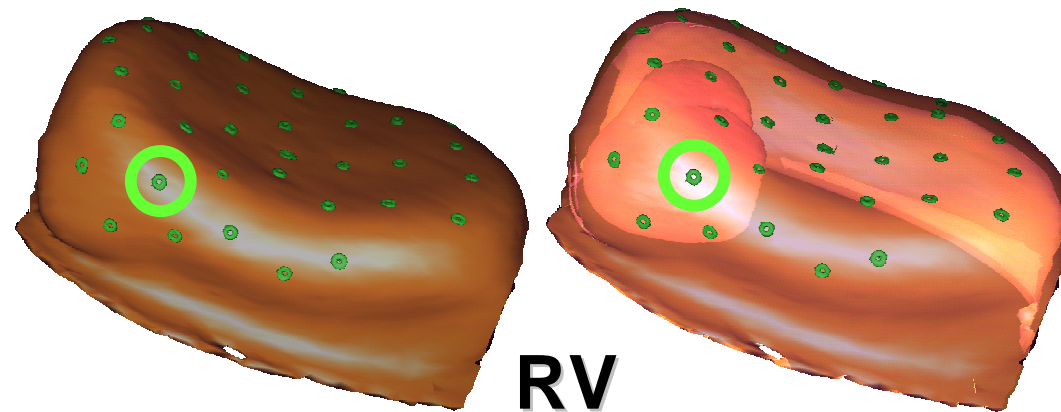
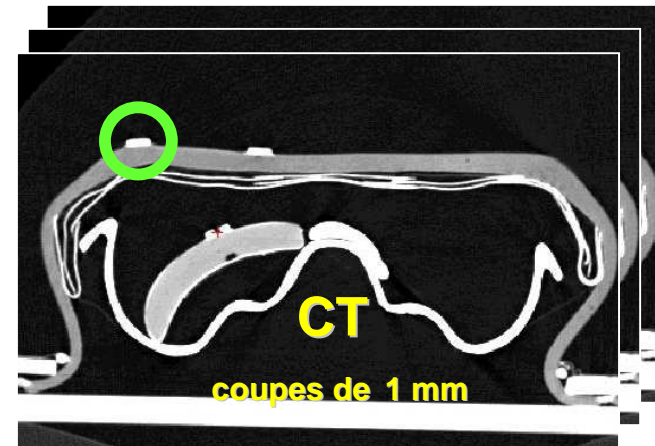
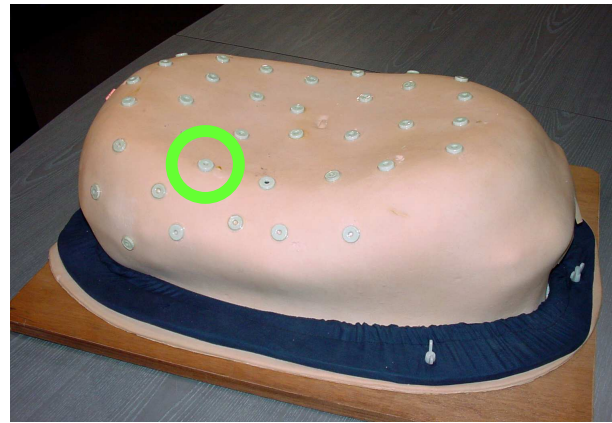
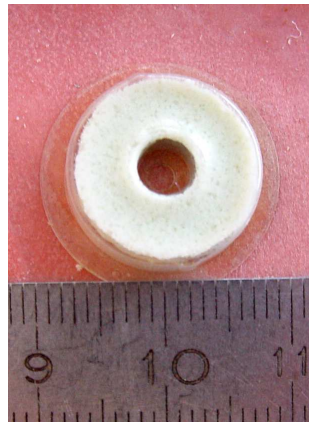
# Interactive Augmented reality

## LIMITS

- **Manual Registration of Virtual & Real**
- **Manual Tools Positioning & Tracking**
- **Manual Organs Tracking**
- **Impossible Virtual Organ Deformation**

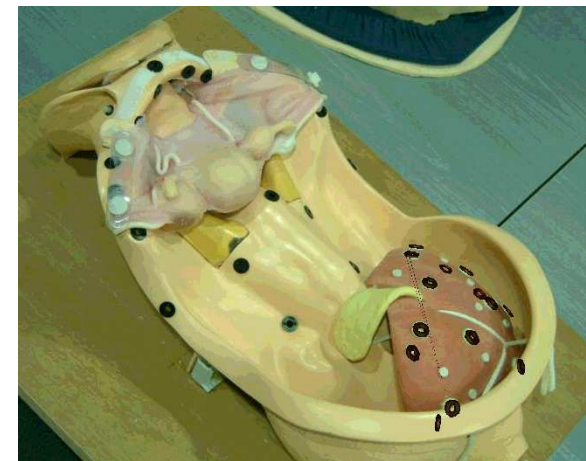
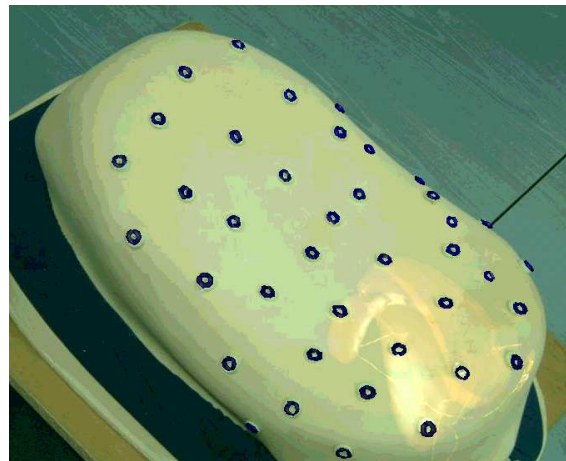
# Automatic Augmented reality

## Automatic registration of 3D view with real view



# Automatic Augmented reality

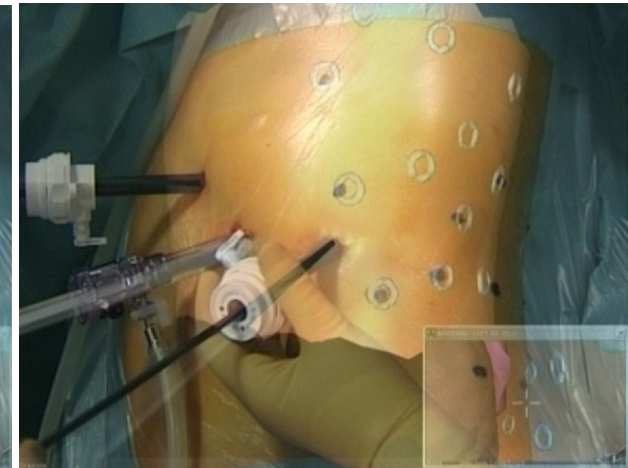
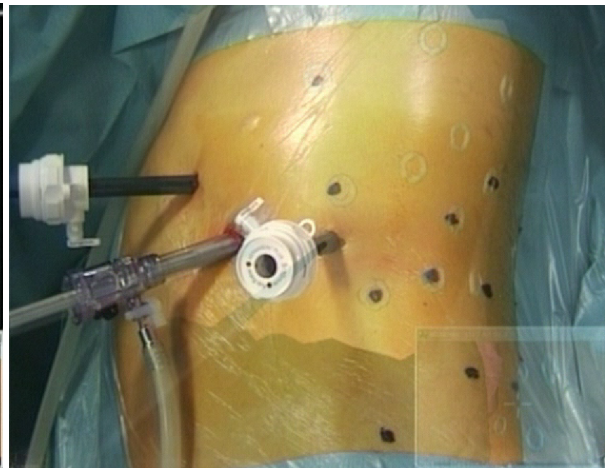
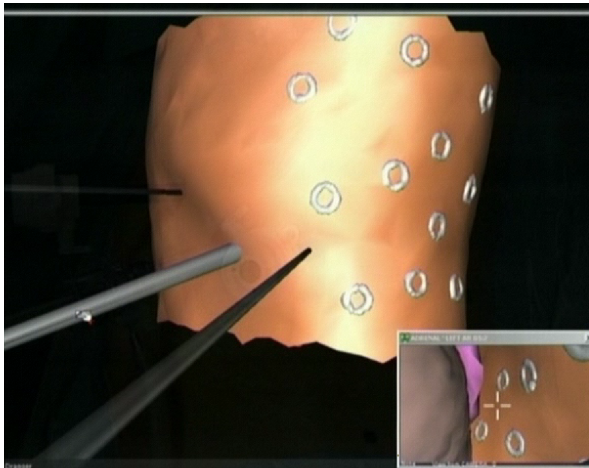
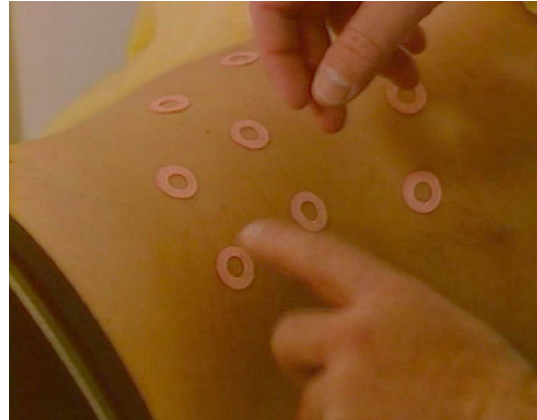
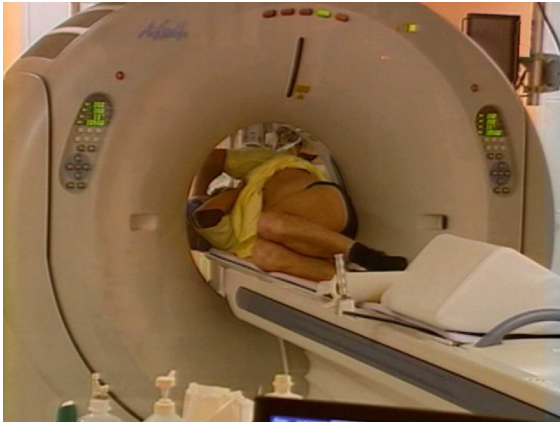
2 cameras  $\leftrightarrow$  human eyes  
Stereoscopic Vision





# Automatic Augmented reality

## Clinical application



# Interactive Augmented reality

## LIMITS

• ~~Manual Registration of Virtual & Real~~

• Manual Tools Positioning & Tracking

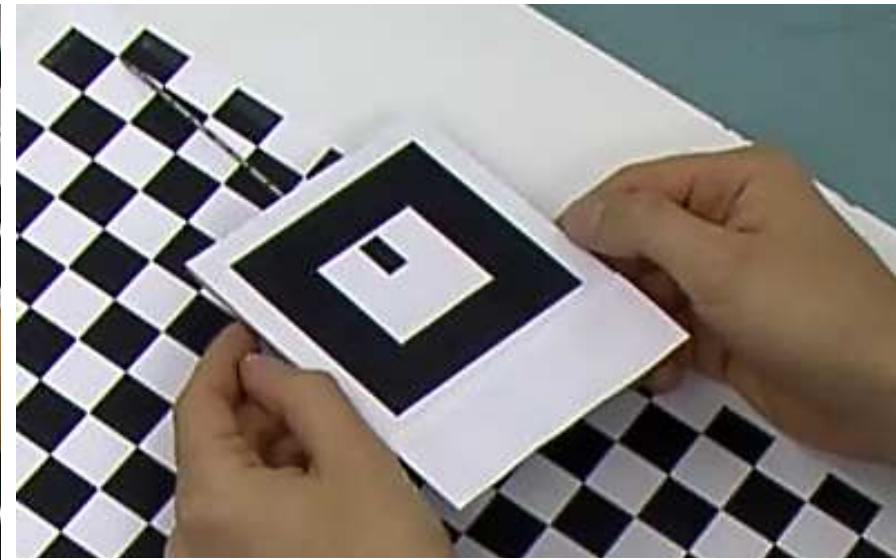
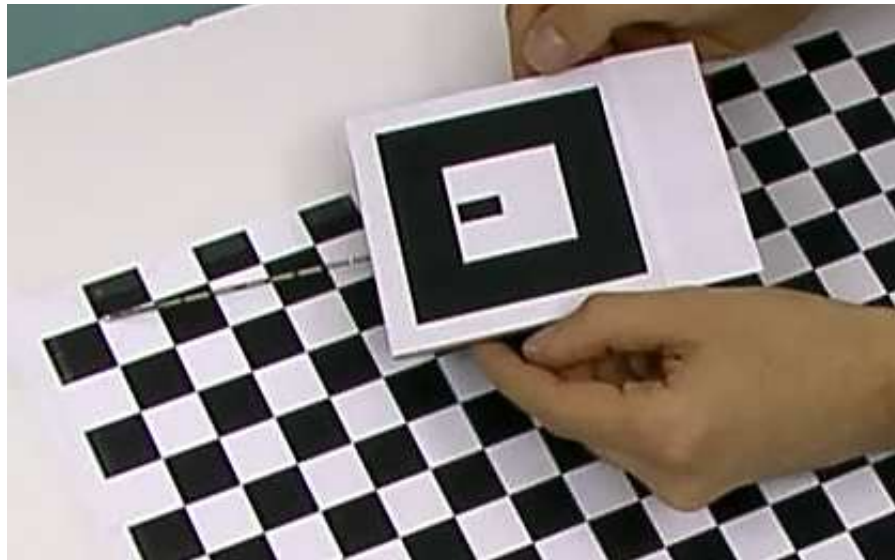
• Manual Organs Tracking

• Impossible Virtual Organ Deformation

# Automatic Augmented reality



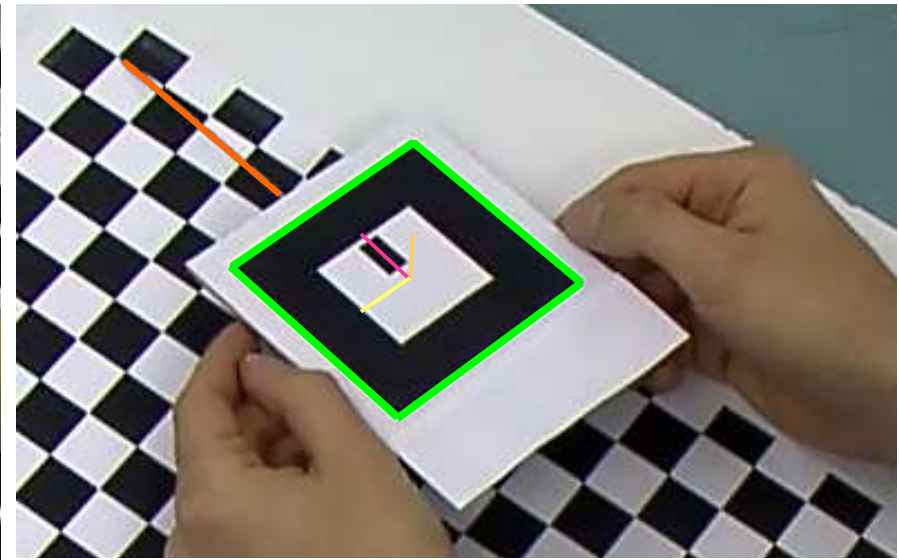
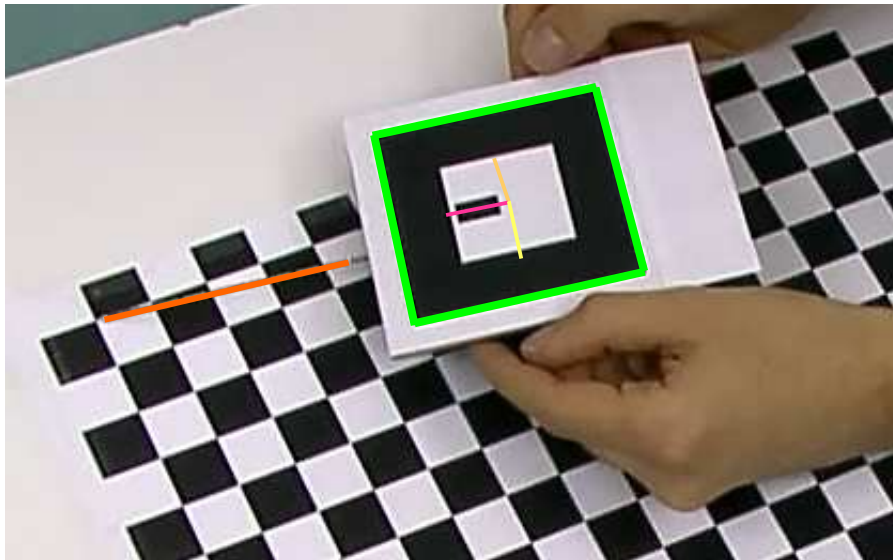
## Automatic Tools Positioning & Tracking Marker placement



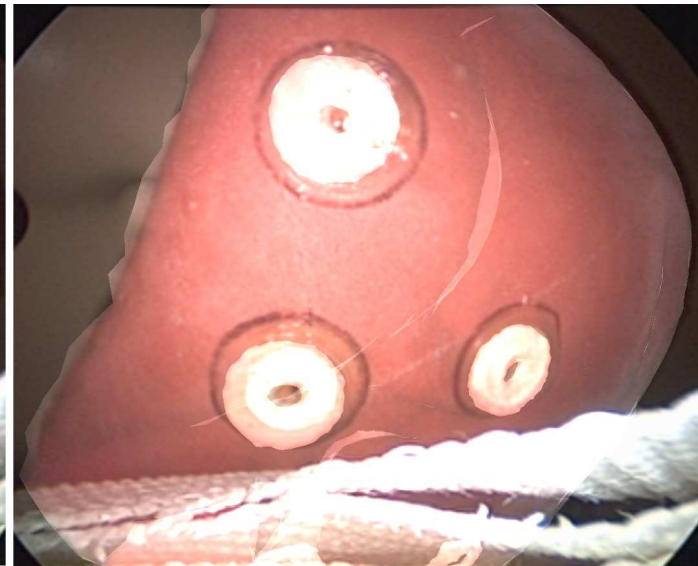
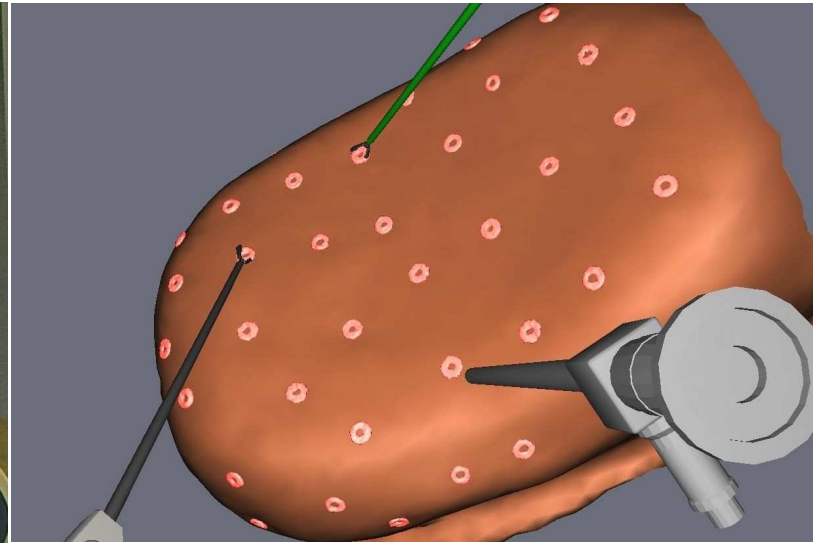
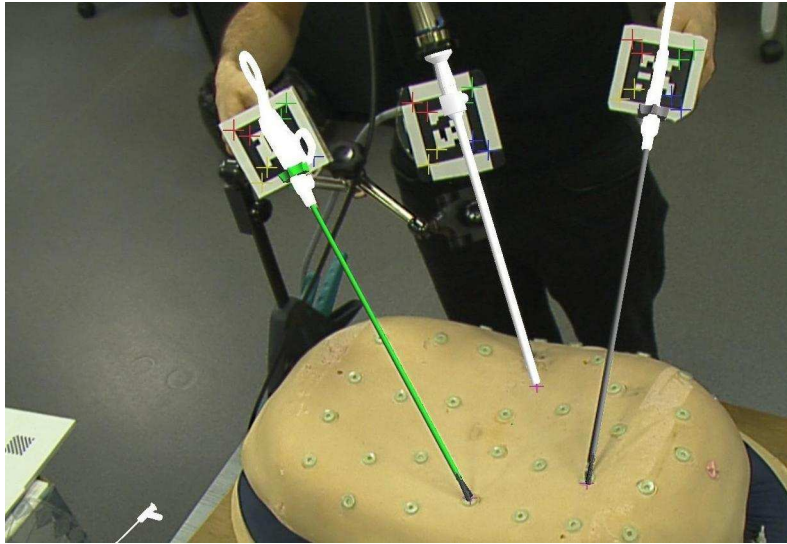
# Automatic Augmented reality



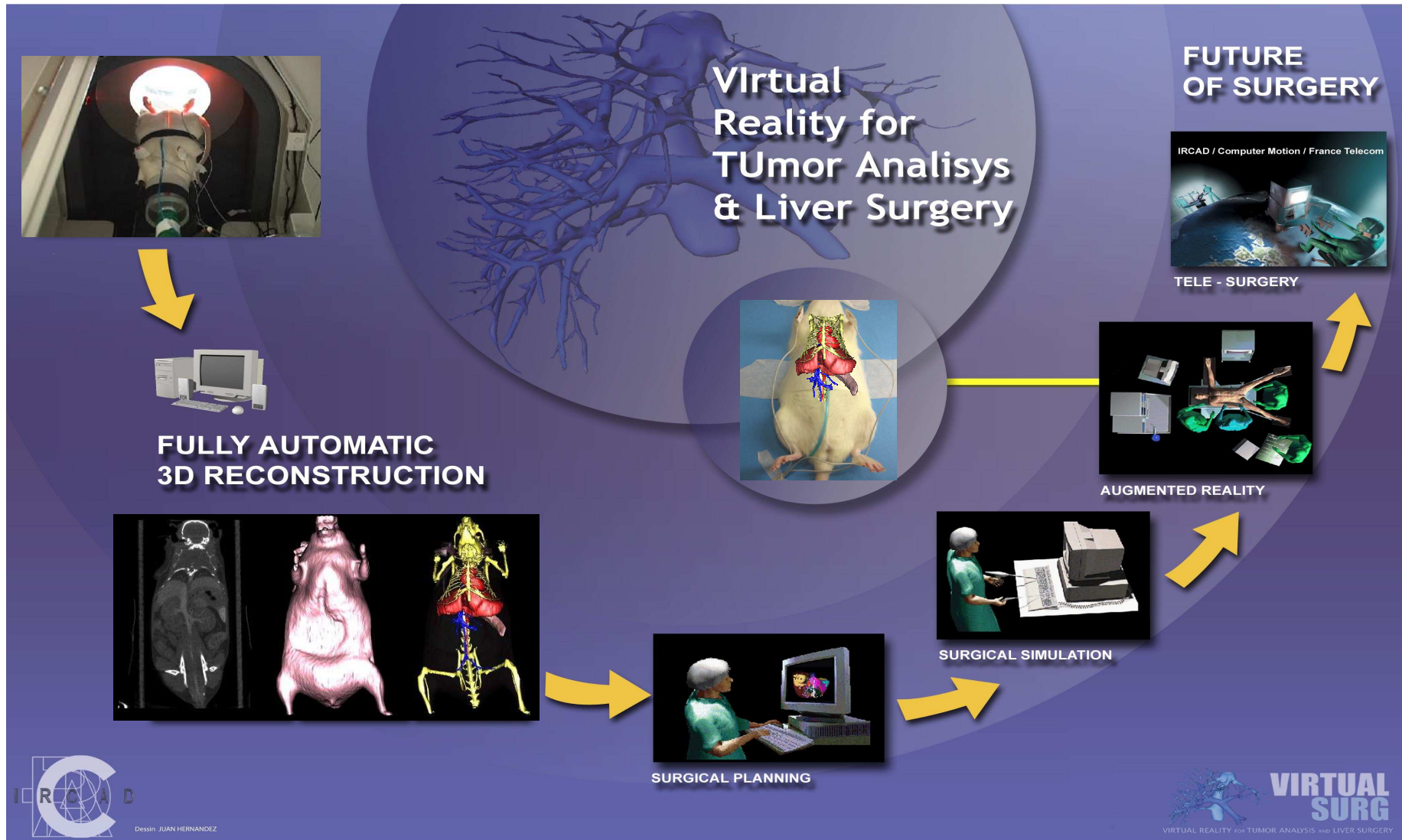
## Automatic Tools Positioning & Tracking Marker placement



# Automatic Augmented reality



# Preclinical Augmented Reality



# Automatic Augmented Reality

## Preclinical studies on rats

*First step : positionning of skin markers*

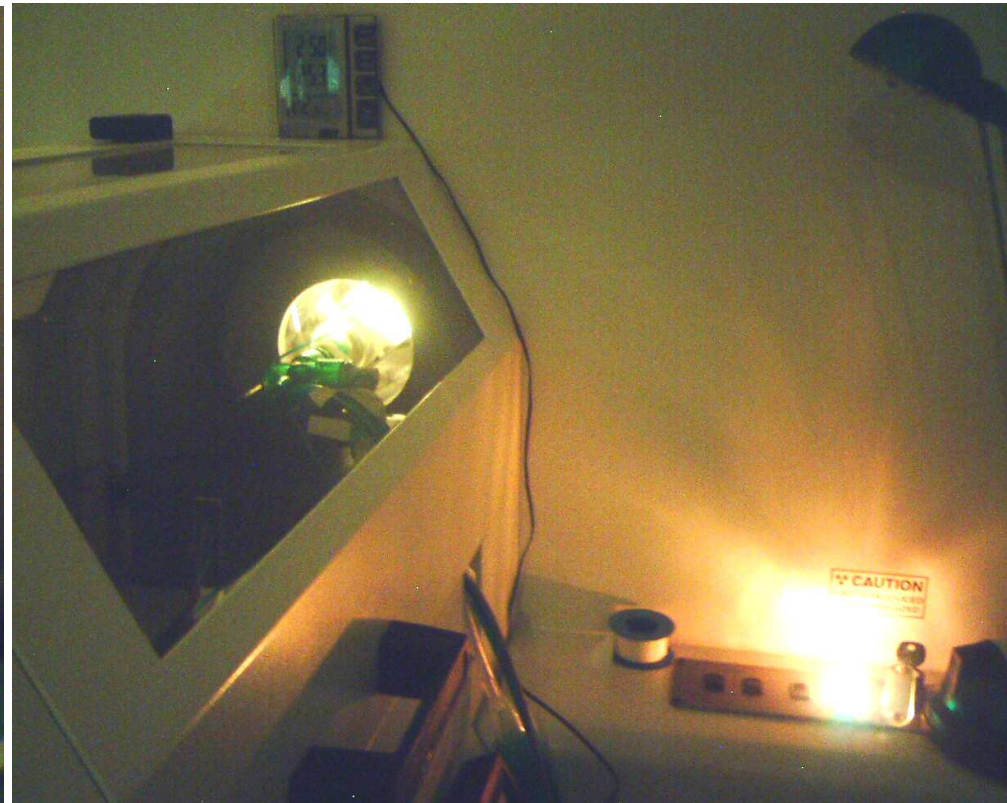


*Easy Shave of the animal with Depilatory cream*

# Automatic Augmented Reality

## Preclinical studies on rats

*Second step : CT-scan of the animal*



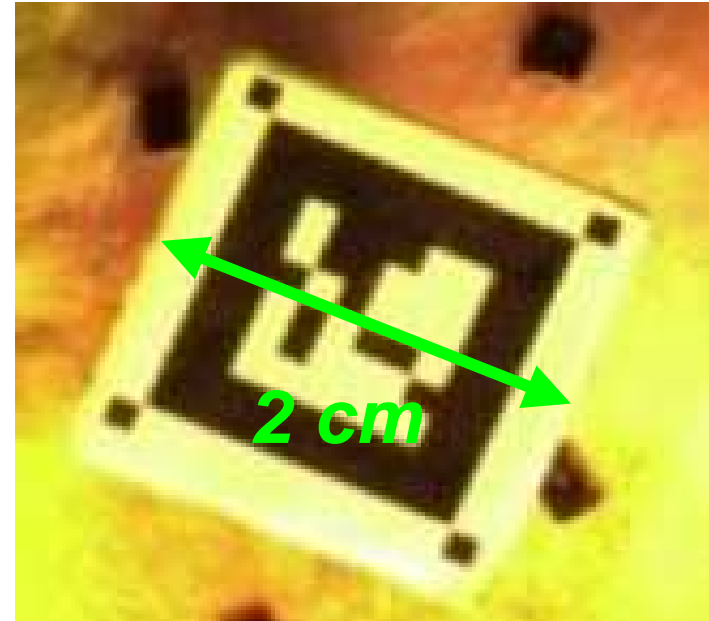
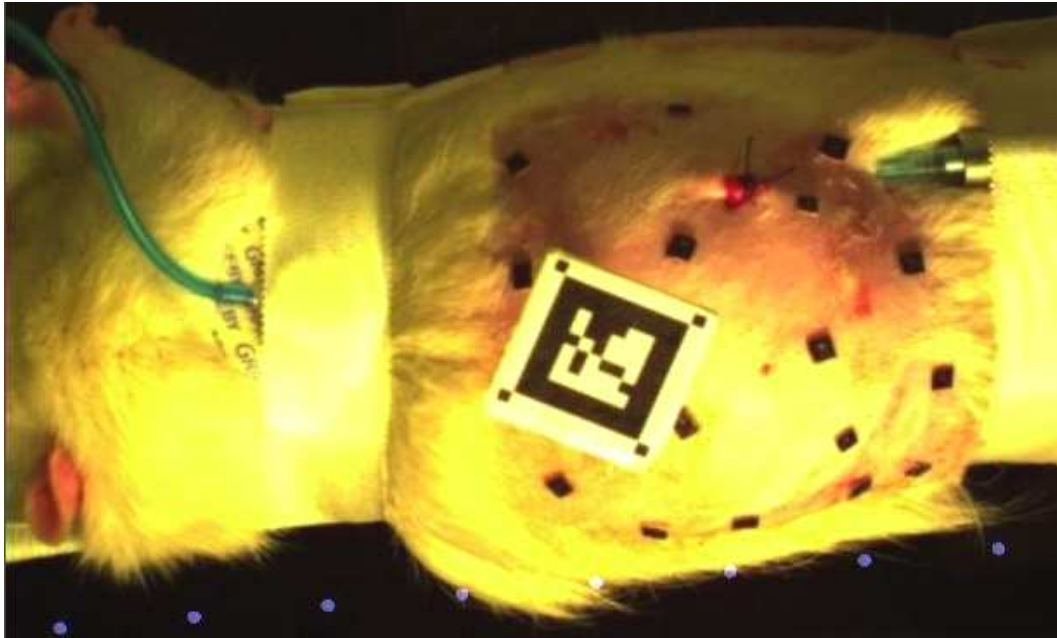
*1 hour after intra-venous contrast agent injection*



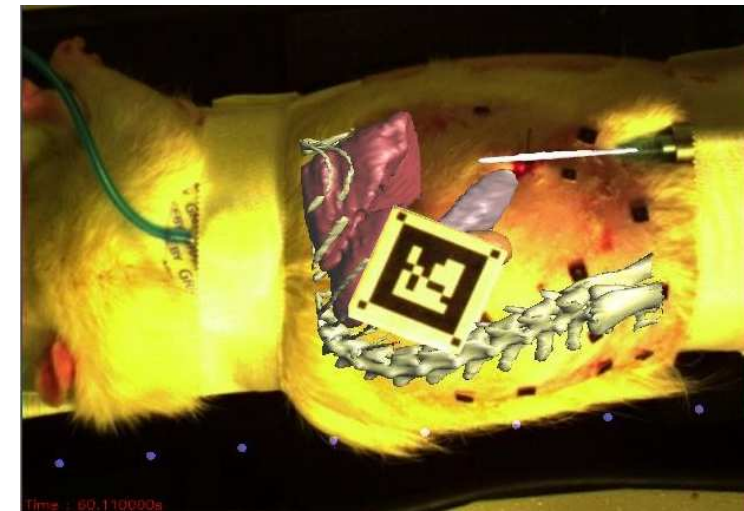
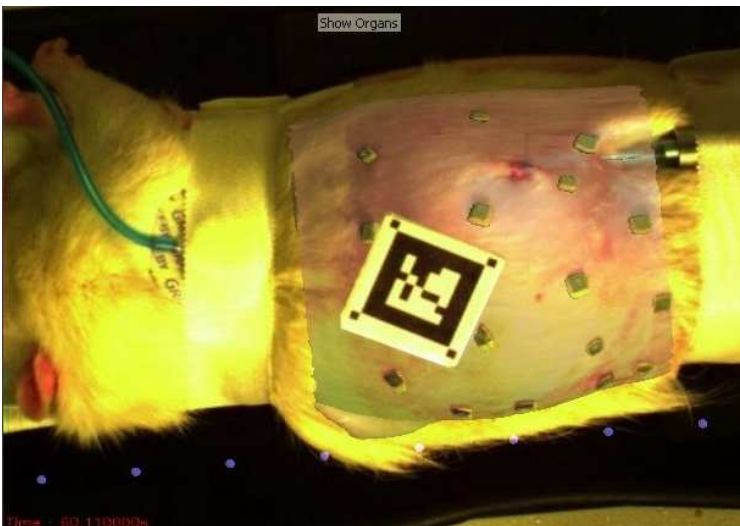
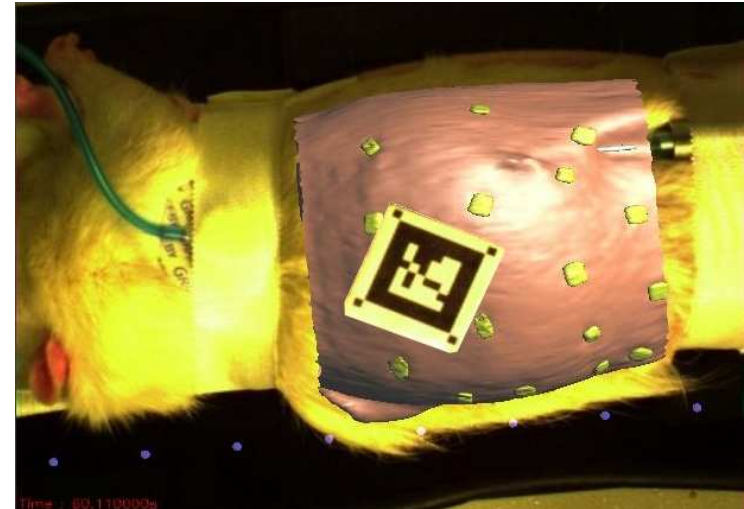
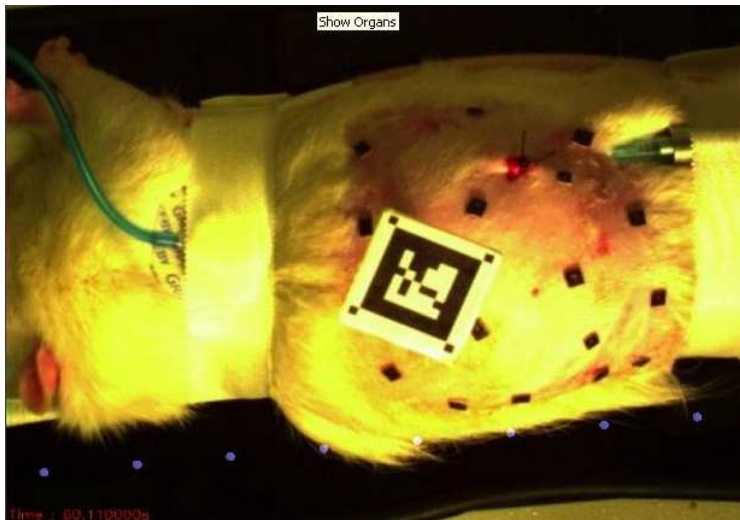
# Automatic Augmented Reality

Preclinical studies on rats

*Last step : Tracking of tool*

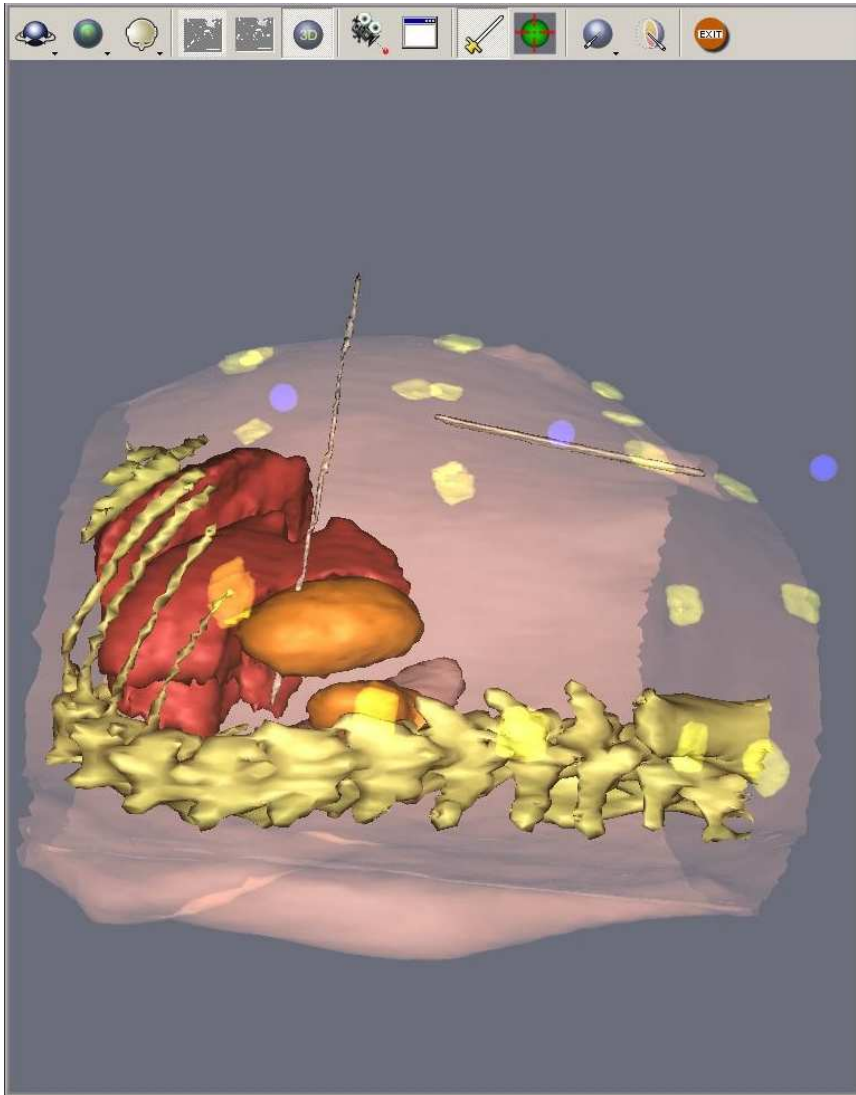


# Automatic Augmented Reality



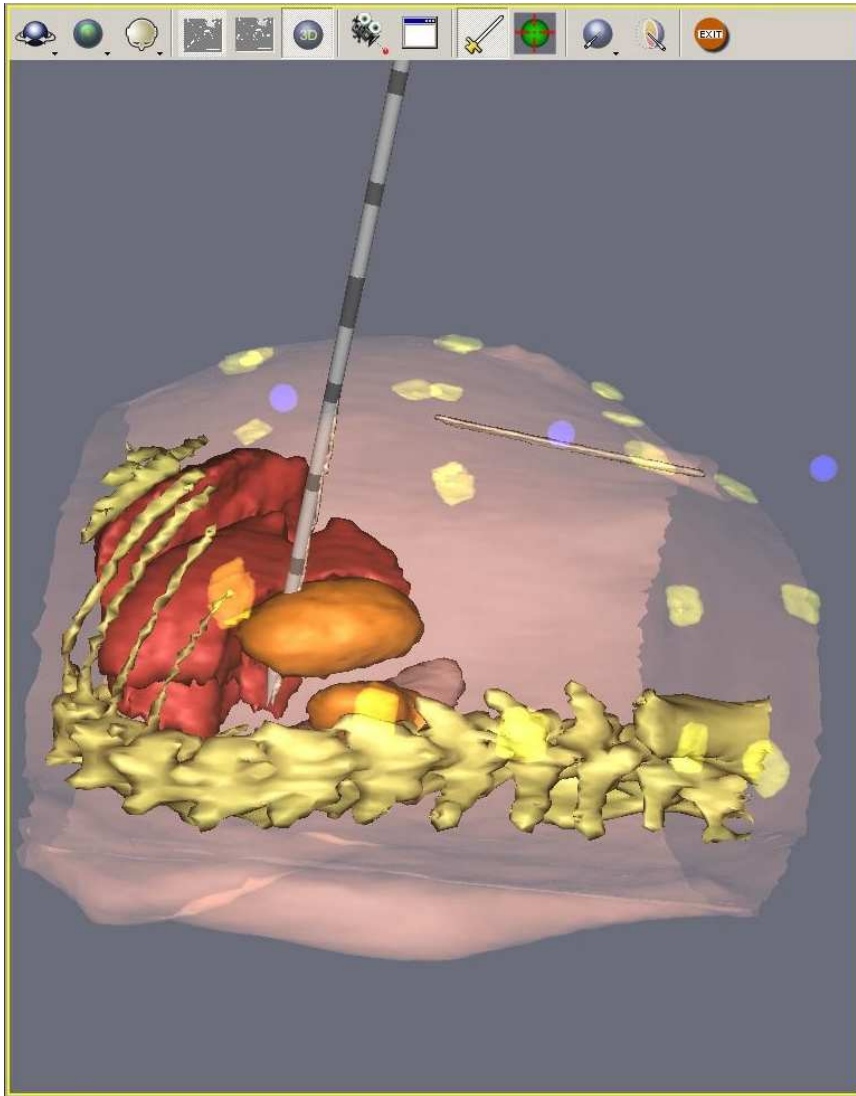
***First Tests on rats***

# Automatic Augmented Reality



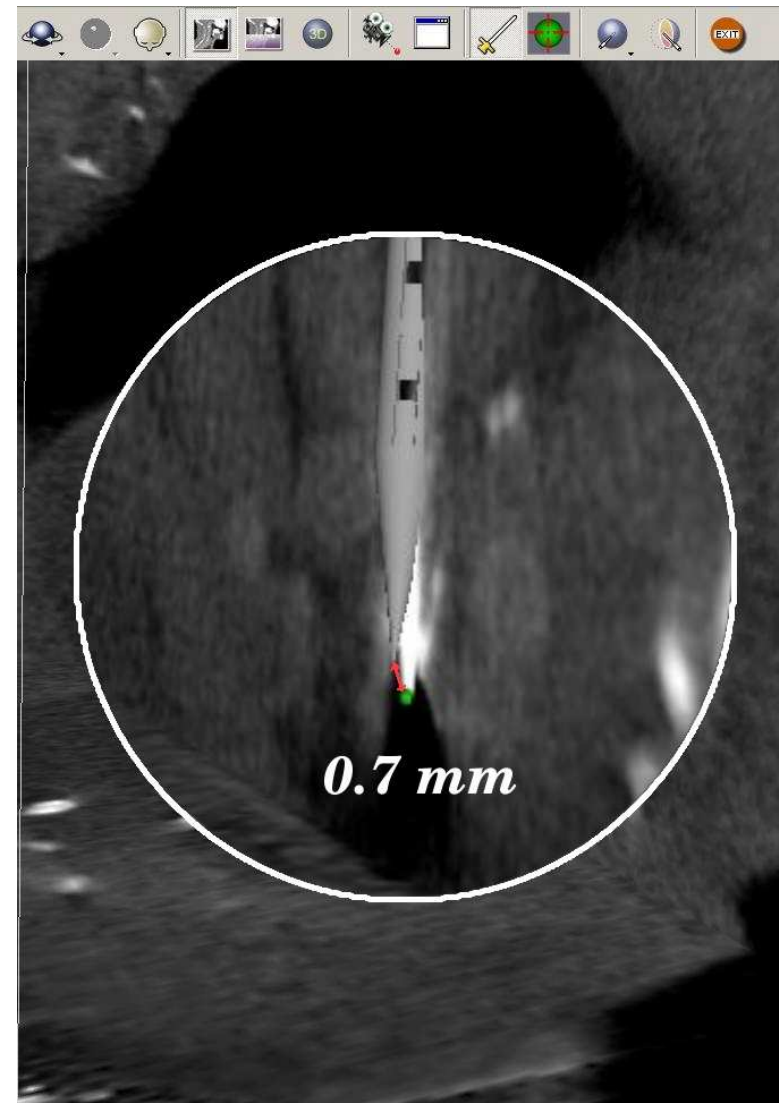
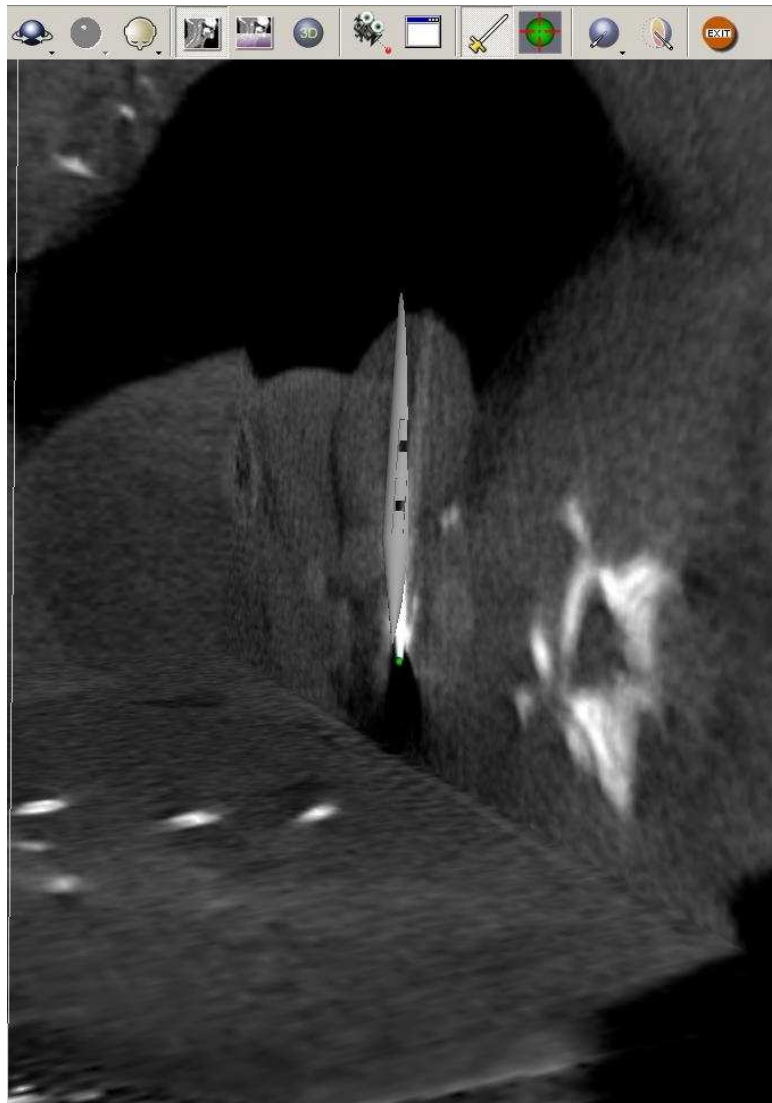
***First Tests on rats (second camera)***

# Automatic Augmented Reality



***First Tests on rats (second camera)***

# Automatic Augmented Reality



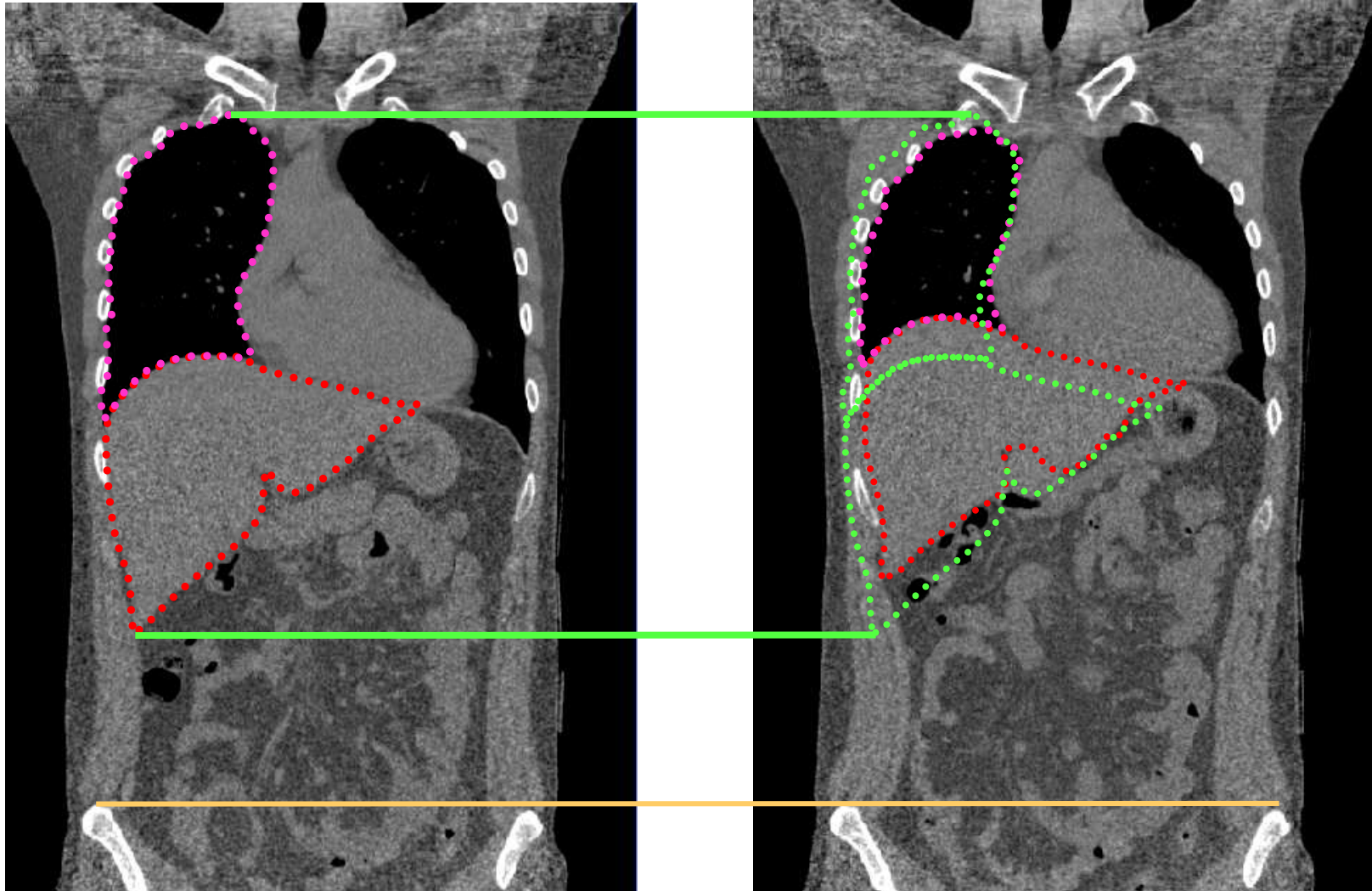
***First Tests on rats (CT-scan control)***

# Interactive Augmented reality

## LIMITS

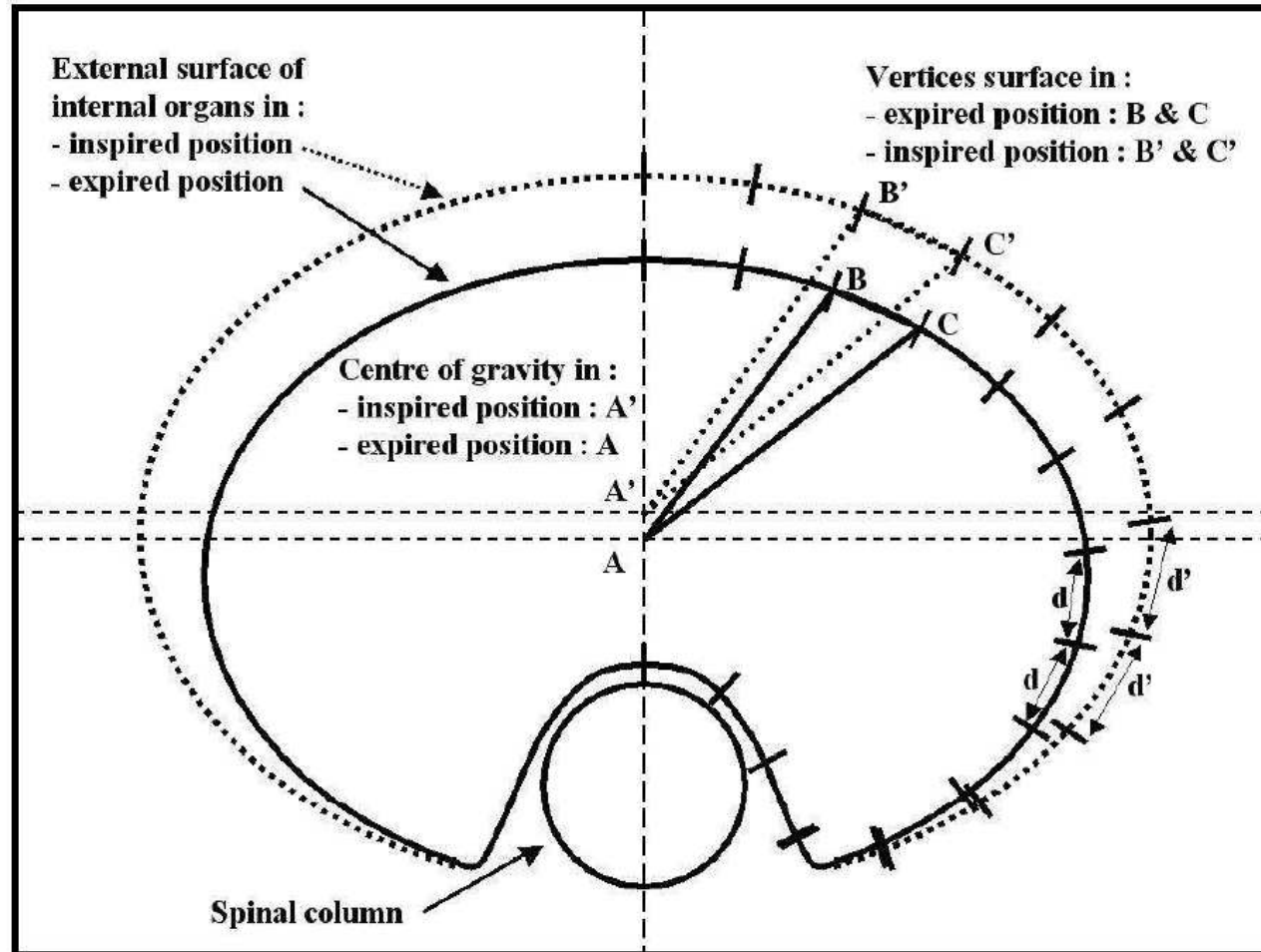
- ~~Manual Registration of Virtual & Real~~
- ~~Manual Tools Positioning & Tracking~~
- Manual Organs Tracking
- Impossible Virtual Organ Deformation

# Augmented Reality



Internal organ motion

# Augmented Reality



Deformation field generation



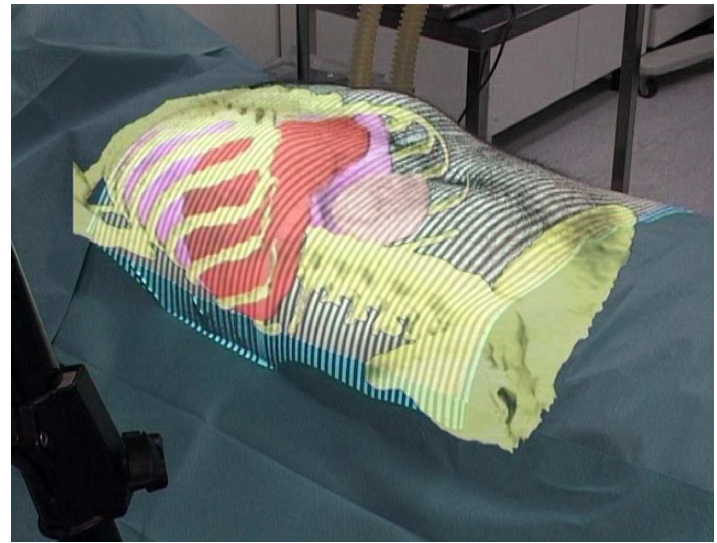
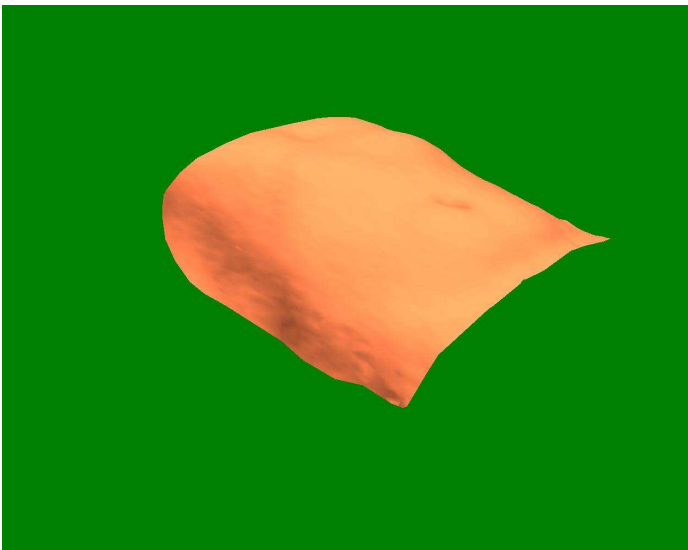
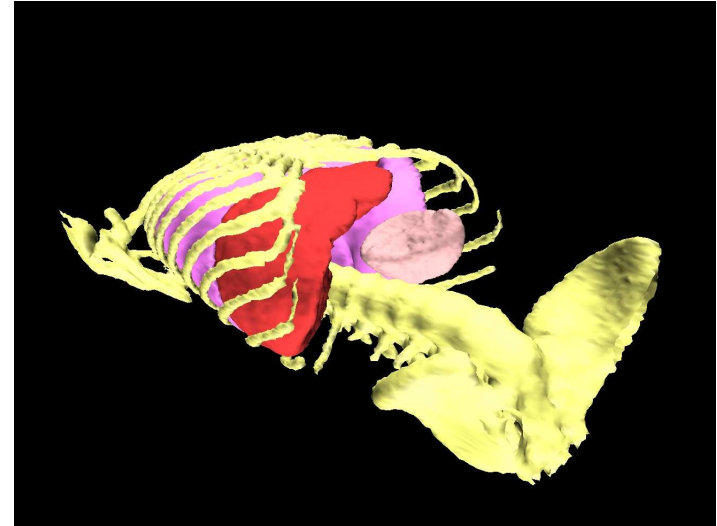
# Augmented Reality



Set up for the human data acquisition

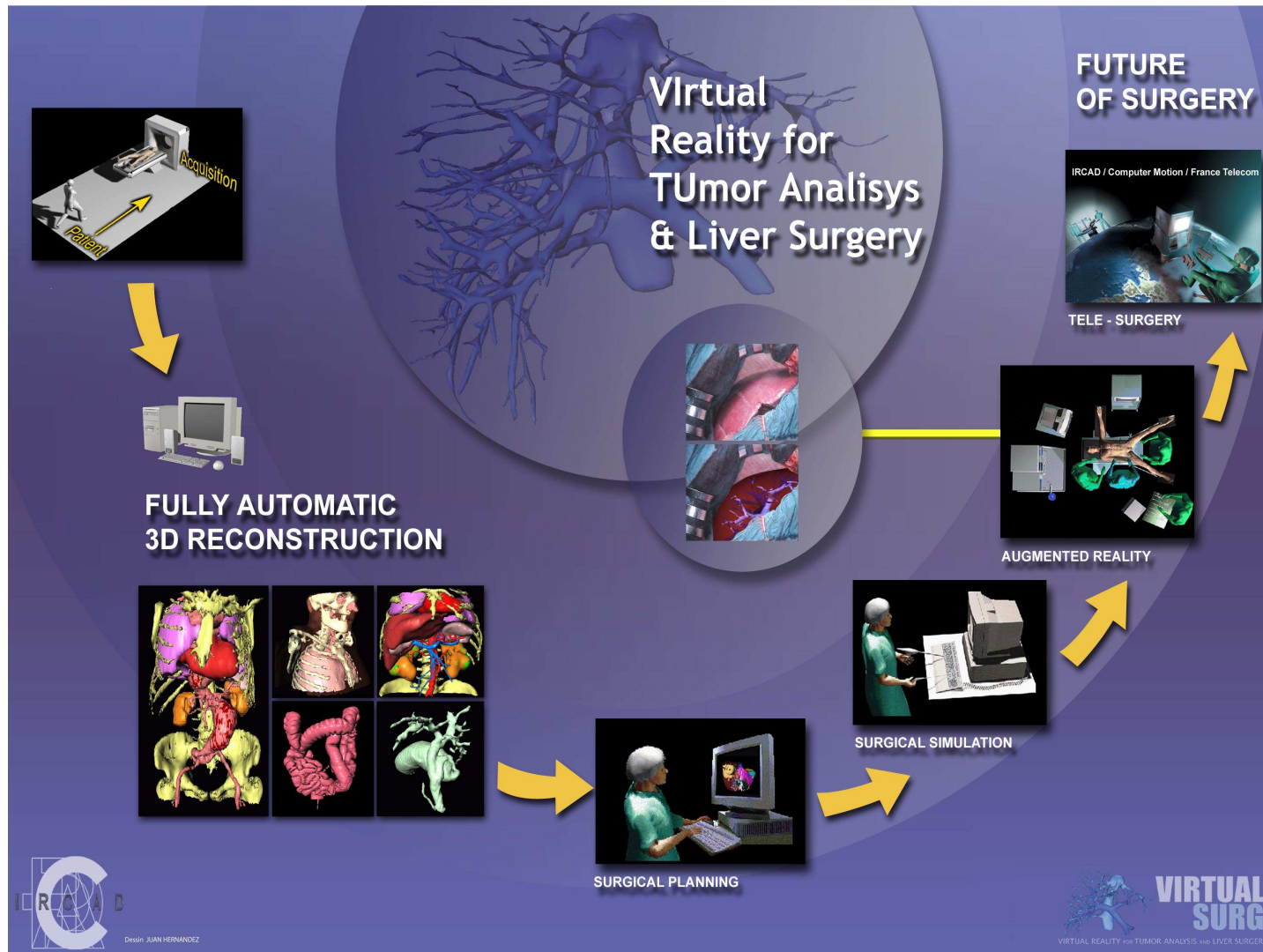


# Structured light to replace markers



**12 images/seconde**

# Robotics



# Robot : TeleSurgery

## 2 Robots, 1 Society : Intuitive Surgical

Da vinci

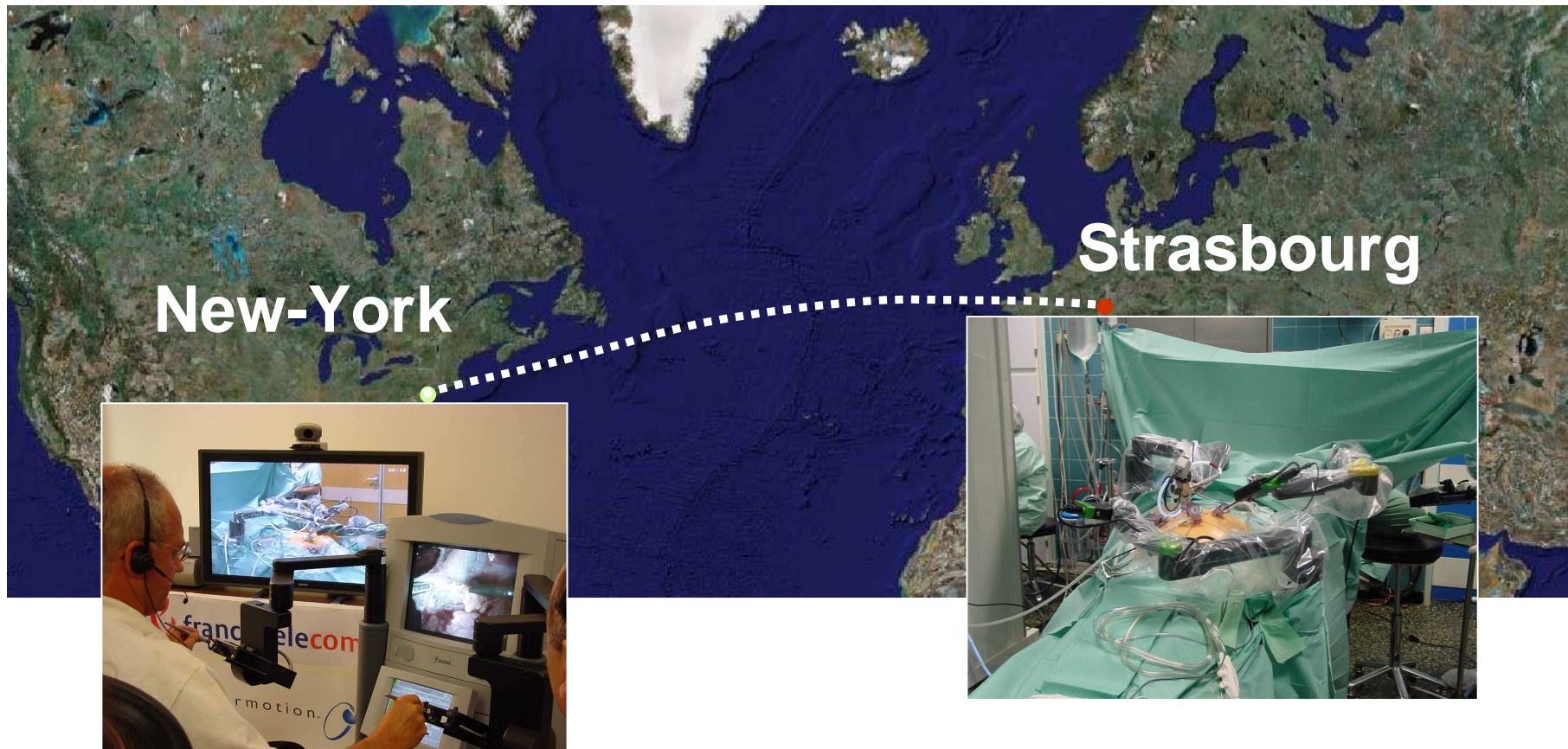


Zeus



# Robotics : An information system

Lindbergh Surgery : September the 7<sup>th</sup> 2001



# A medical revolution ?...

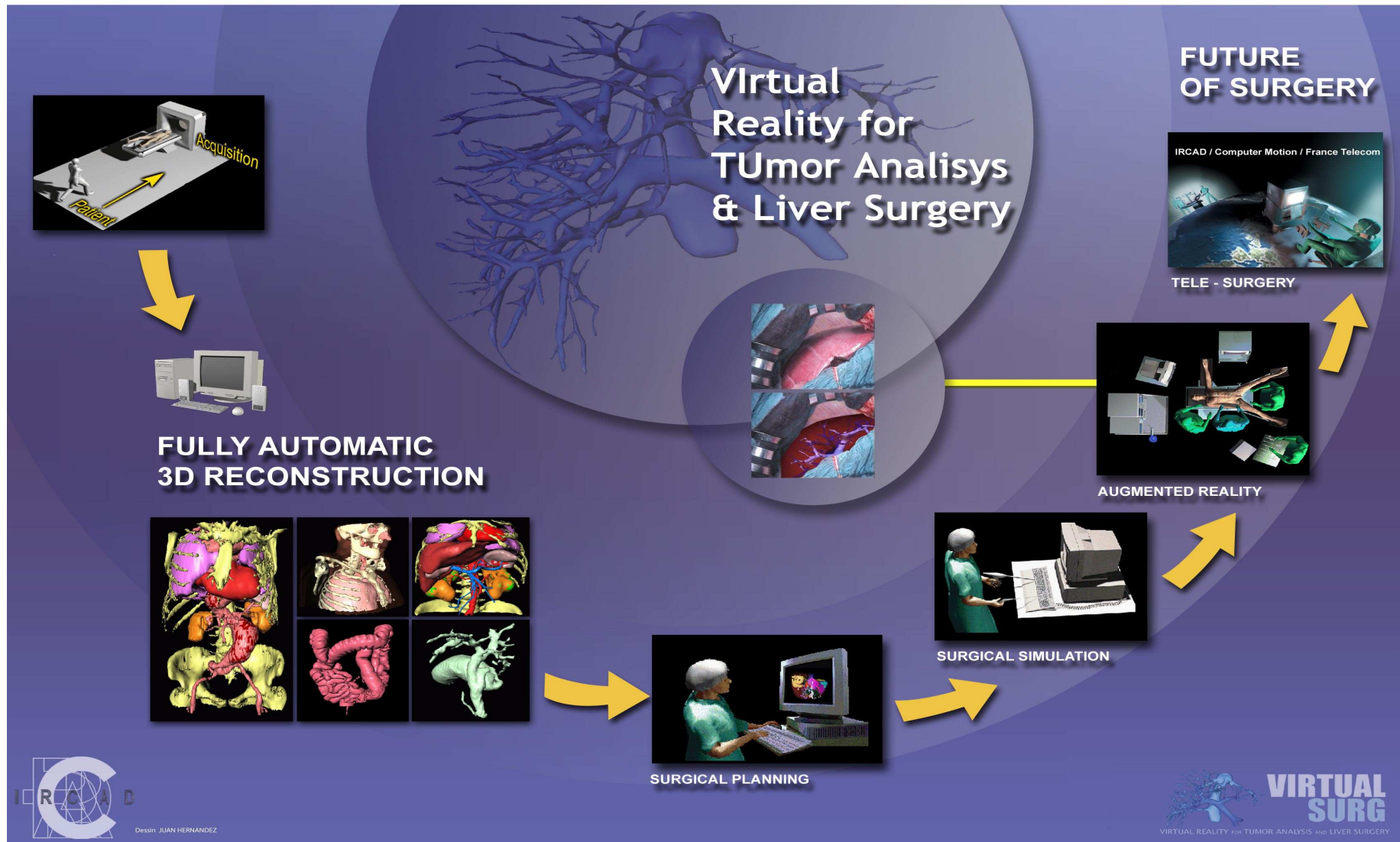


# Robotic Tele-mentoring



Courtesy of *InTouch Health*

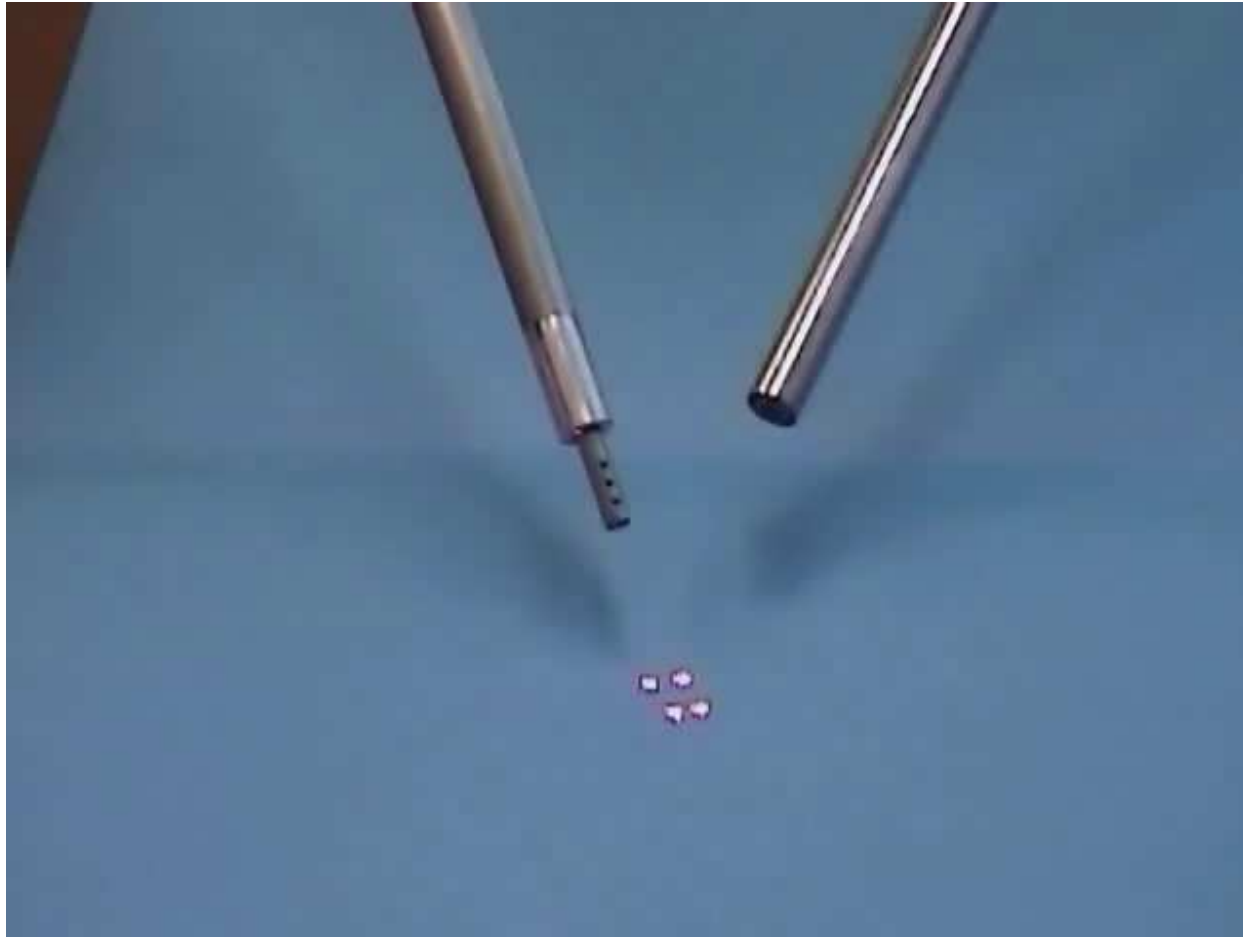
# Robotics → Automation





# Automated Robotics

## Visual Control



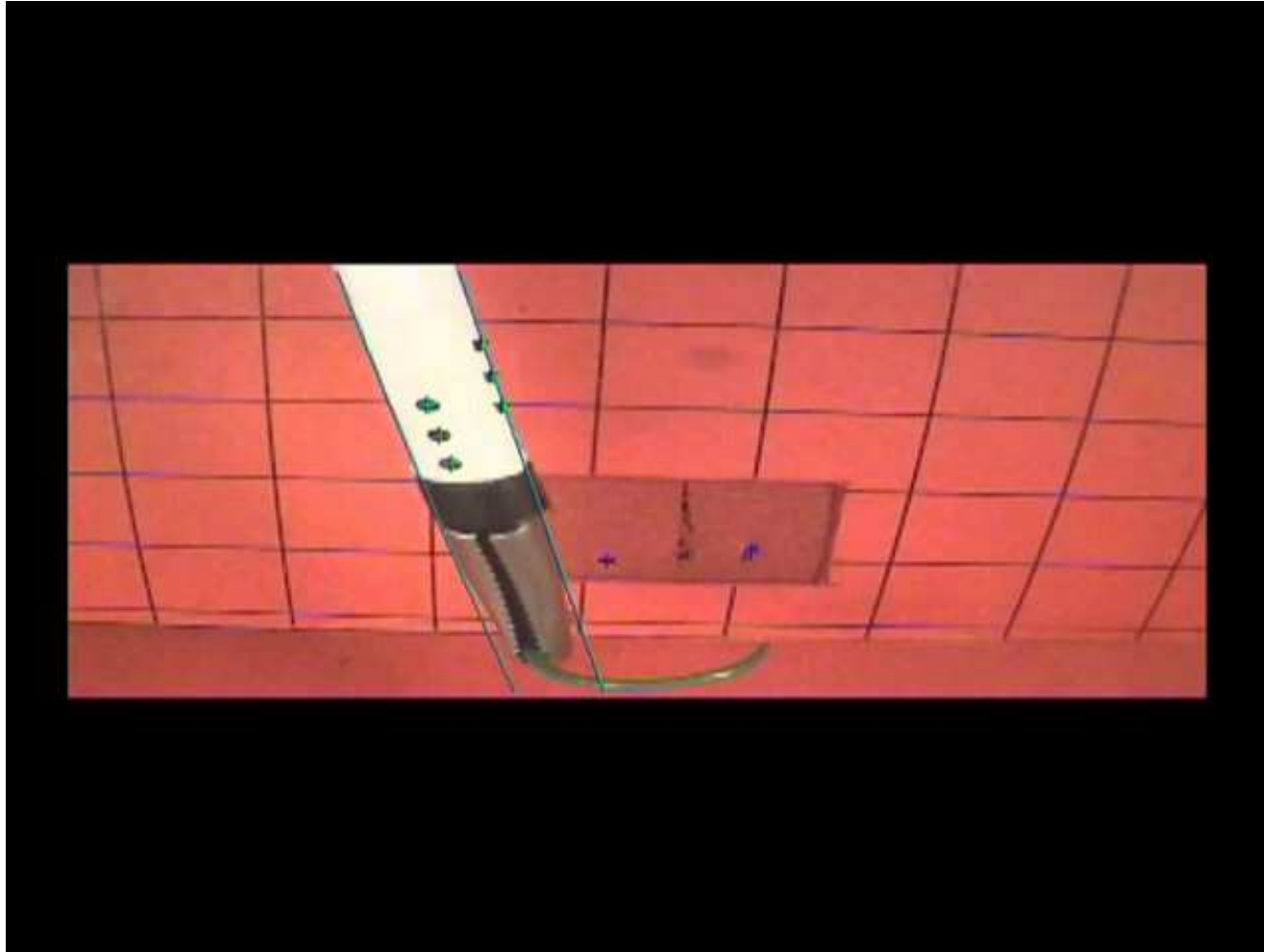
# Automated Robotics

## Visual Control

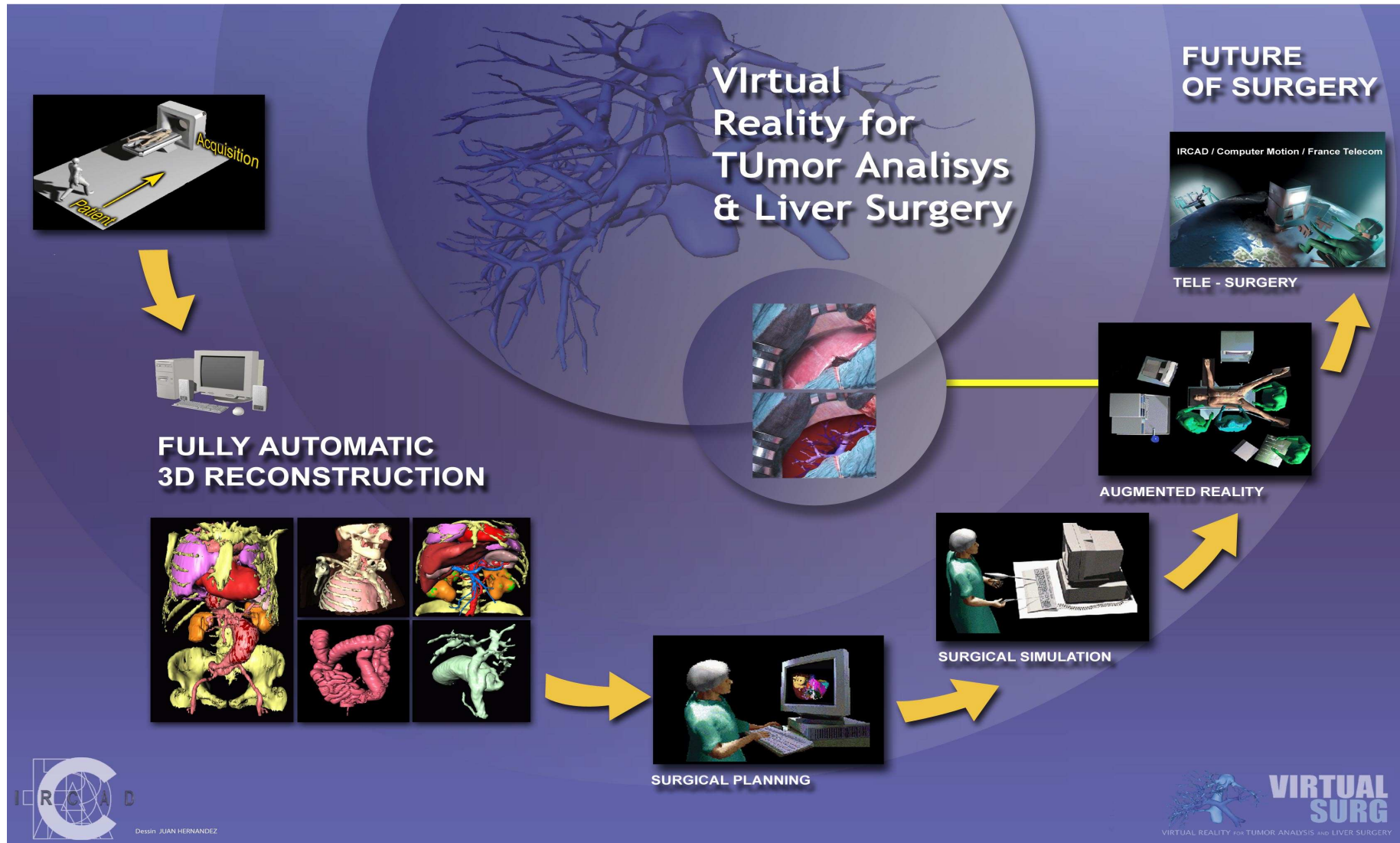


# Automated Robotics

## Visual Control



# Next Step : Without Visible Scare





# ANUBIS

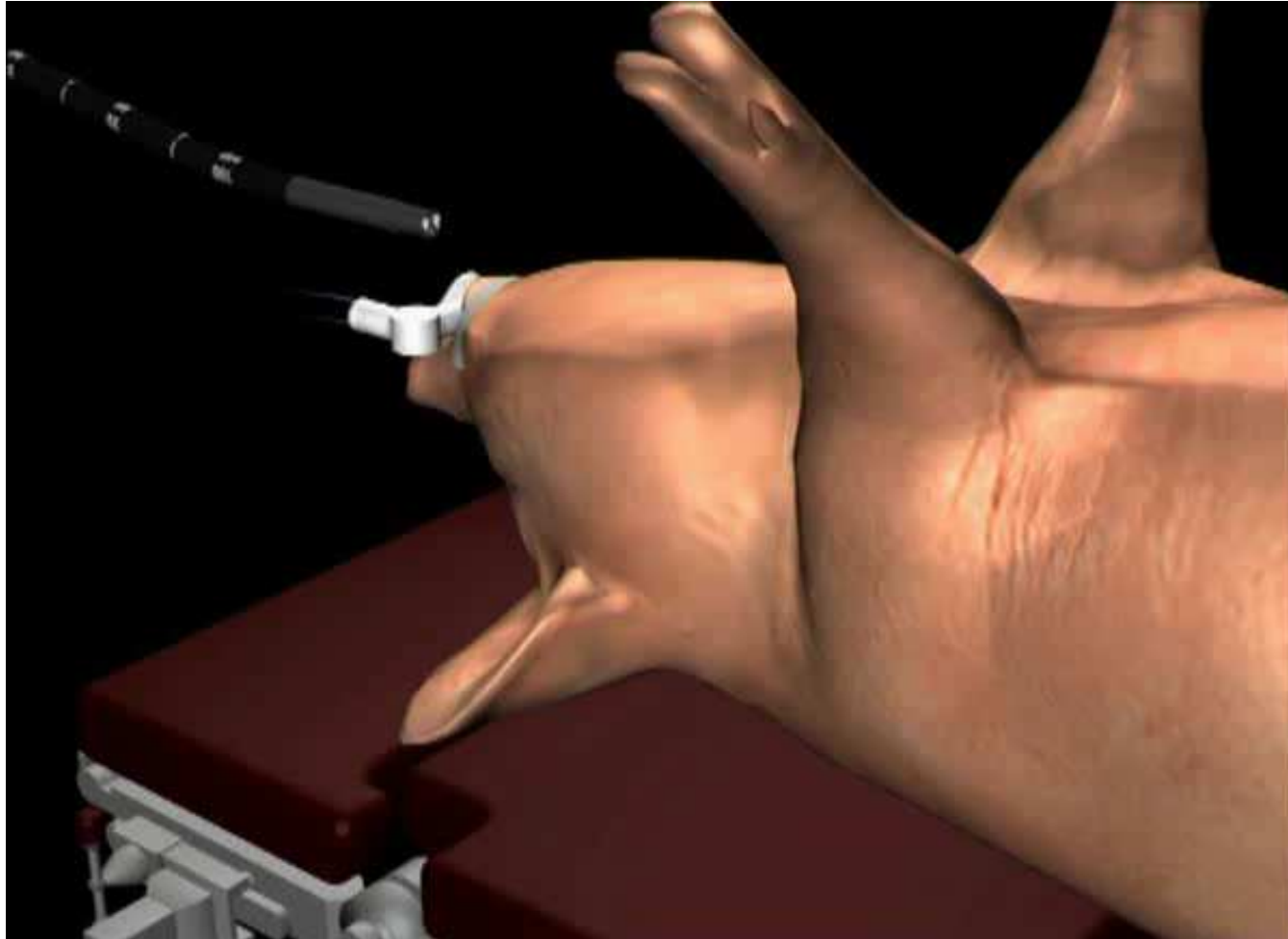
## 1rst labelled Project



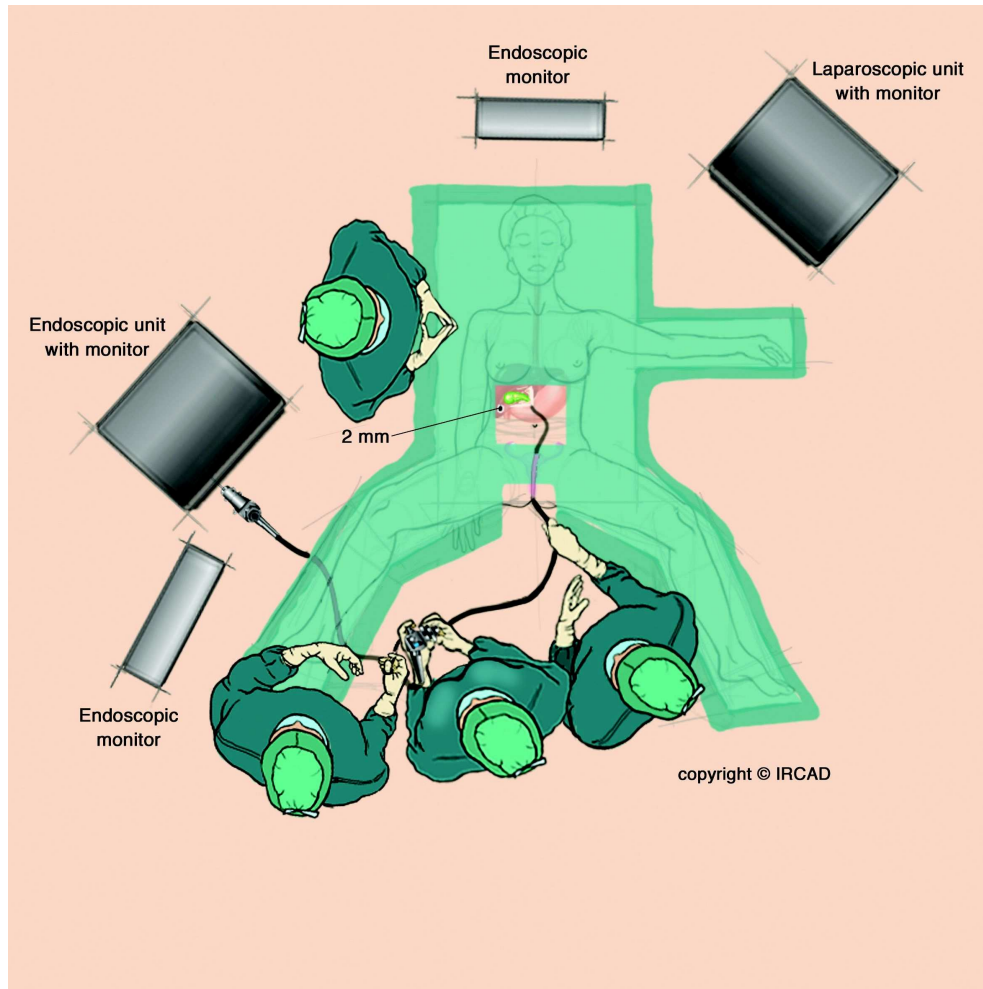
# First System



# Transgastric Surgery



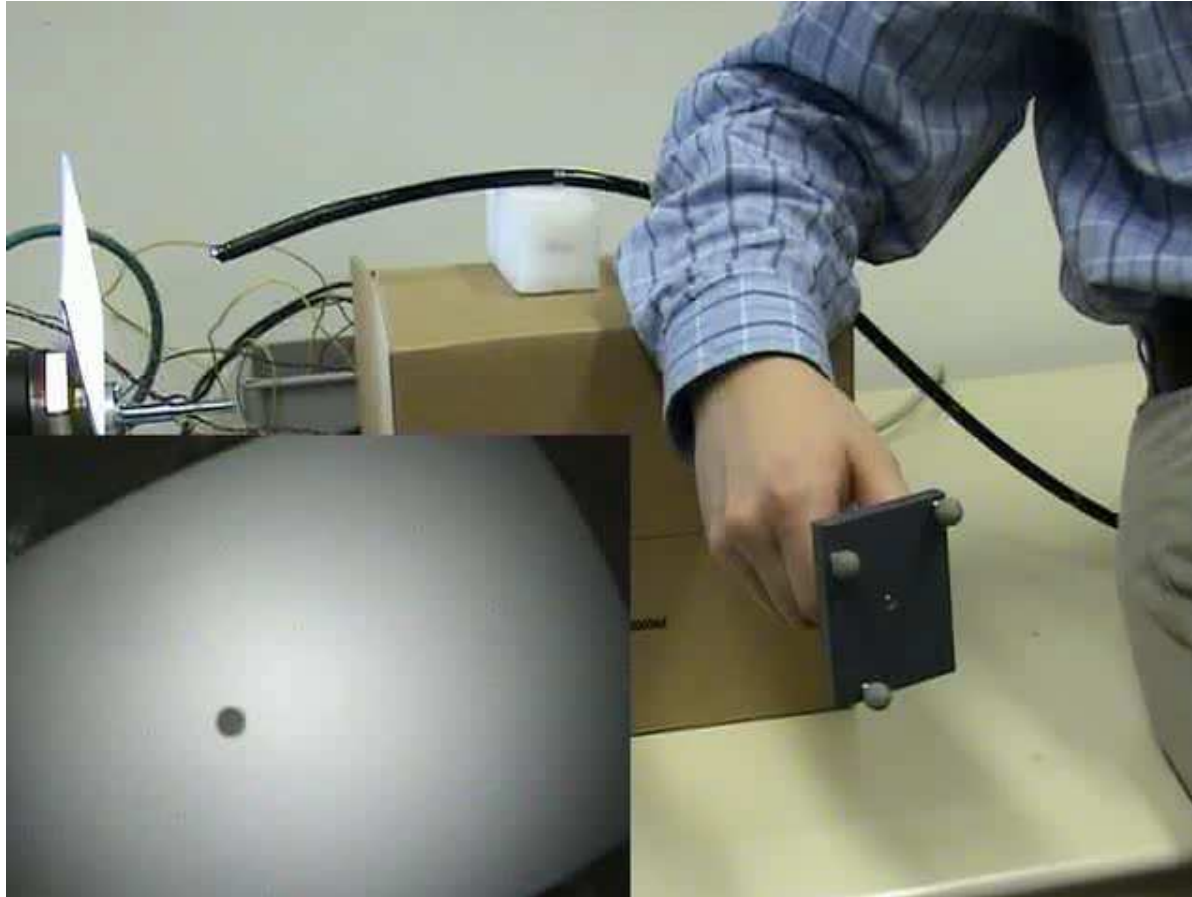
# First Woman Transluminal Surgery





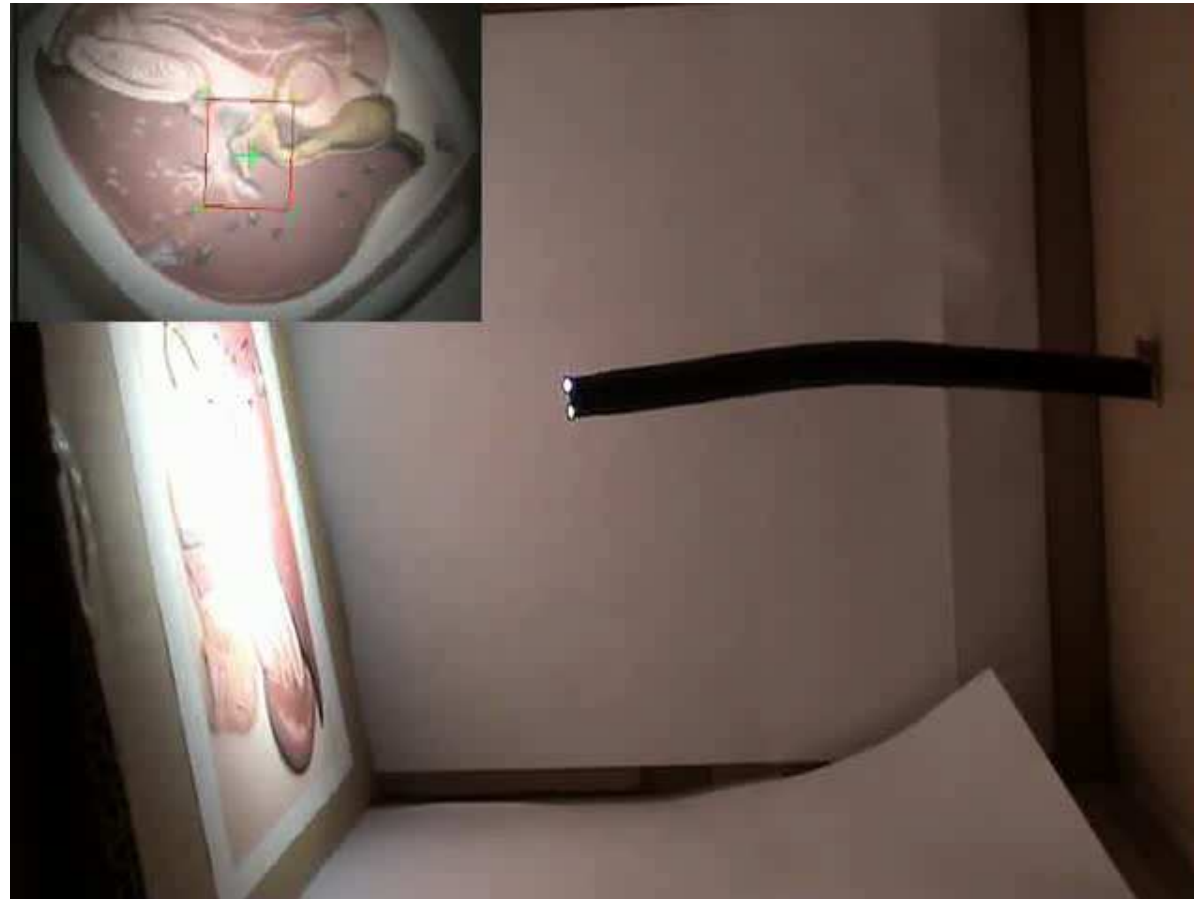
# Anubis : Endoscope Robotisation

## Easy interactive flexible endoscope control



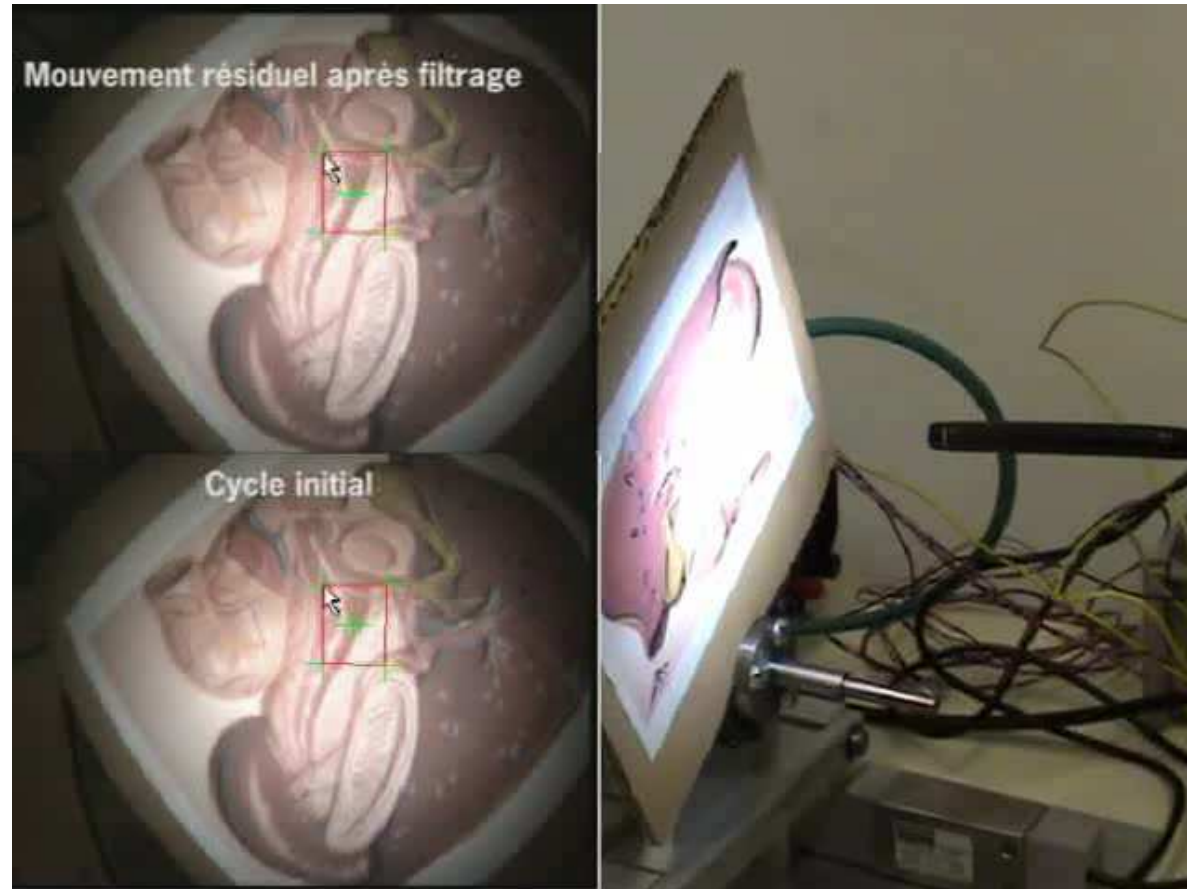
# Anubis : Endoscope Robotisation

## Automatic Flexible endoscope control



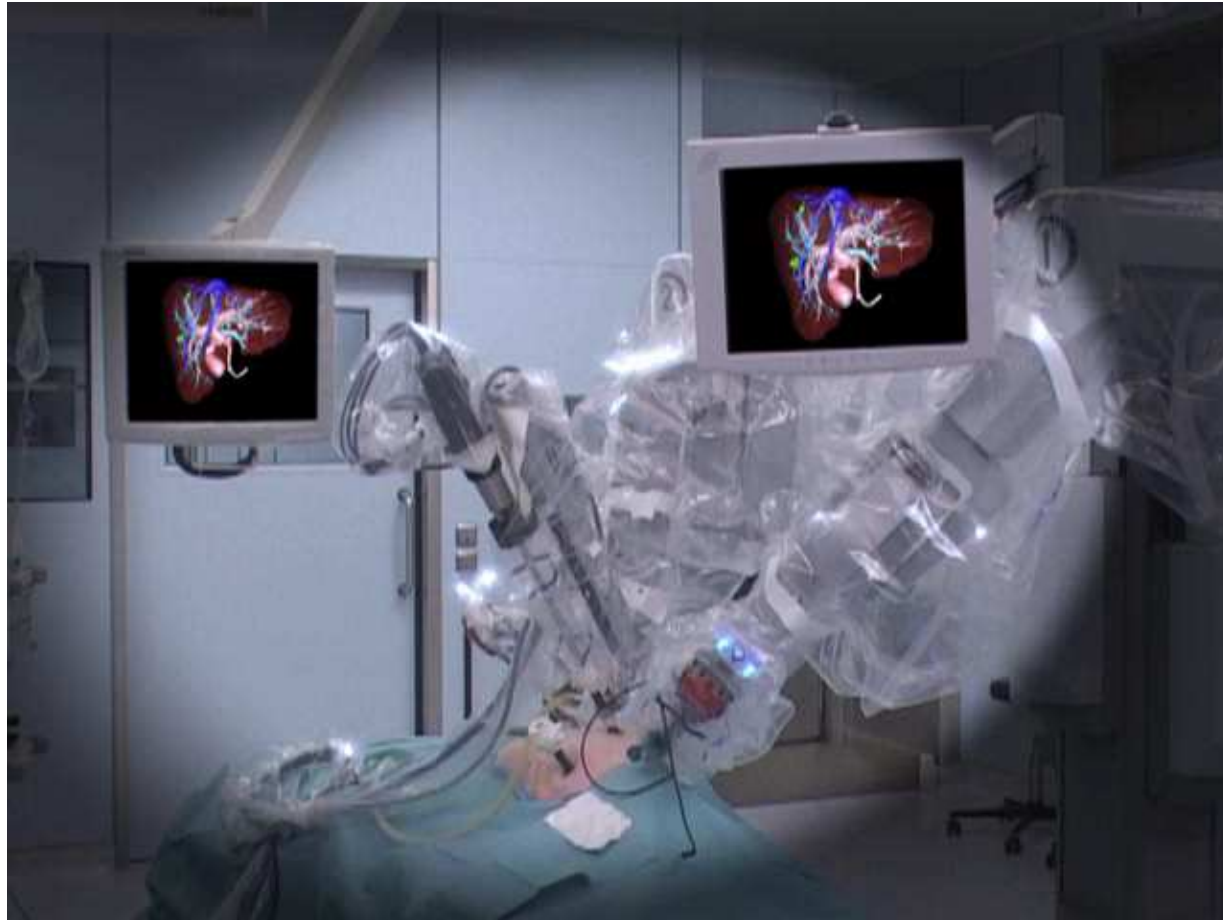
# Anubis : Endoscope Robotisation

## Automatic Flexible endoscope control



# Conclusion

## Automated procedure



# Conclusion

**Robot for a better control of the surgery**



**Under the control of surgeons**

# Thanks for your attention



## ***R&D Team of IRCAD***