

# ***Background***

- ✓ **Imaging modalities (eg CT, MRI):**
  - Data acquisition ↑
- ✓ **Computers:**
  - Speed ↑
  - Graphics display ↑
  - Availability from open operating systems

**L I N U X** (<http://www.linux.org>)



**challenging new applications**

# *Outline*

## ✓ Registration

## ✓ What is Augmented Reality (AR)?

- „Ingredients“ of AR - Systems
- Applications and first results

## ✓ Robotics

- Defnition
- Types
- Applications

# ***What is Augmented Reality (AR)?***

- ☑ **Overlay of artificial „target information“ over real-worldview**
- ☑ **Virtual scenery adopts itself to the position of the viewer Technology:**
  - Visualization devices such as head-mounted displays(HMD)
  - Position tracking or pose estimation
  - Interfacing to 3D-visualization systems

# *Visualization Devices*

## ☑ **Features to consider:**

- Optics
- Focal problems, display quality, parallax error, calibration
- Appropriate visualization, tracking, latency, weight
- Acceptance
- Appropriateness for given applications, acceptance of end users

# *Graz Approach*

## ✓ Features:

- Now fixed on operator's head
- 2 Monitors:  
800x600 px  
(for every eye)
- infinitely variable  
Reality  $\leftrightarrow$  Virtuality



# *Question?*



- ☑ **Can we (as radiologists) exploit these emerging technologies for improving patient care?**

# ***Attack.....***

## **✓ Computer-Assisted Tumor Ablation**

- Usage of an Augmented Reality System (AR) for:
  - ✓ Visualisation
  - ✓ Planing
  - ✓ Navigation
  - ✓ Success Control

## **✓ Multidisciplinary Team**

- Radiologists
- Surgeons
- Informatics / Telematics
- Biomedical Engineering / Image Procesing

# *Augmented Reality System*

✓ Overview

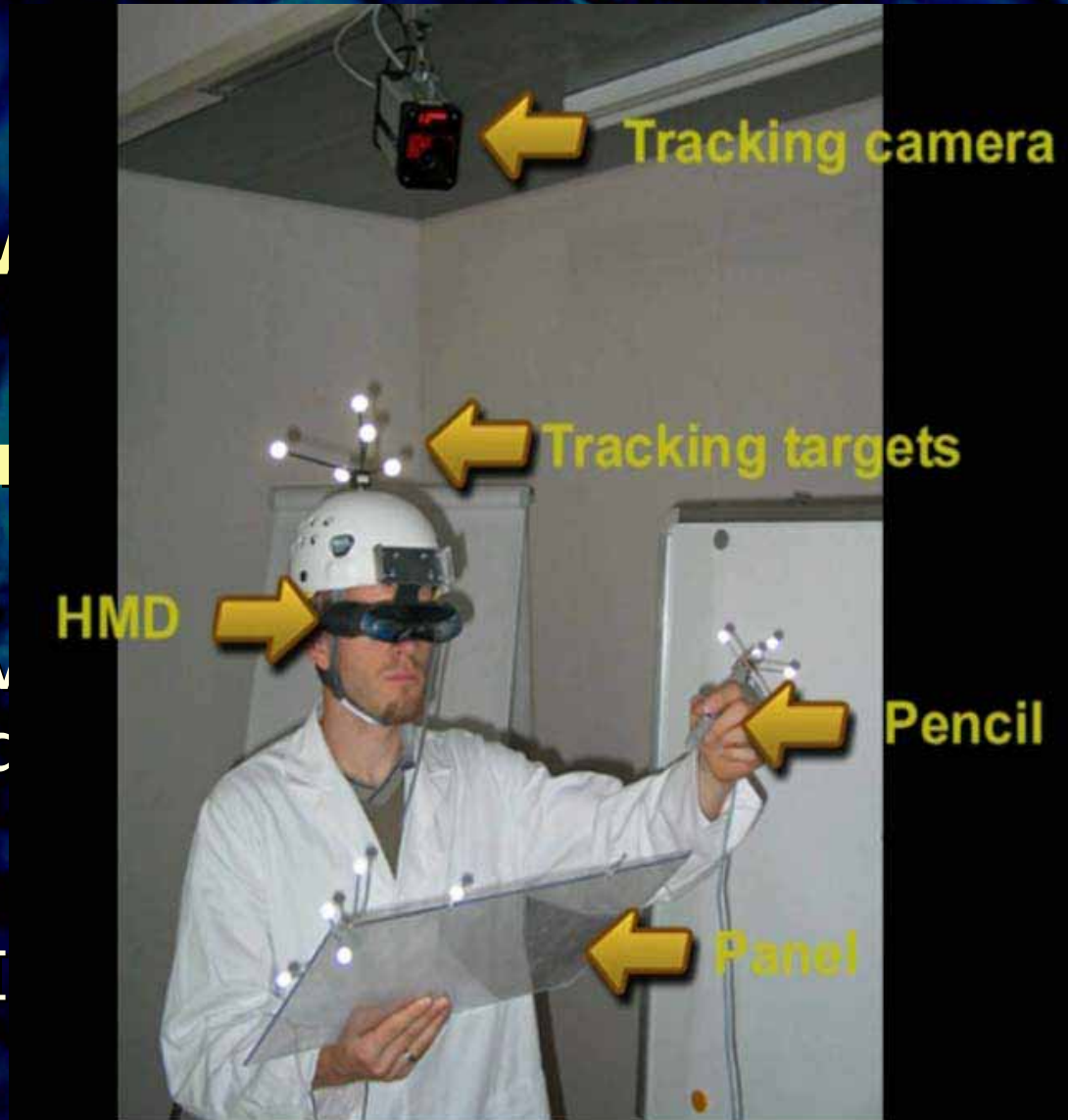
✓ Visualization

- Virtual

- Content

- Interaction

- Interface



Information"

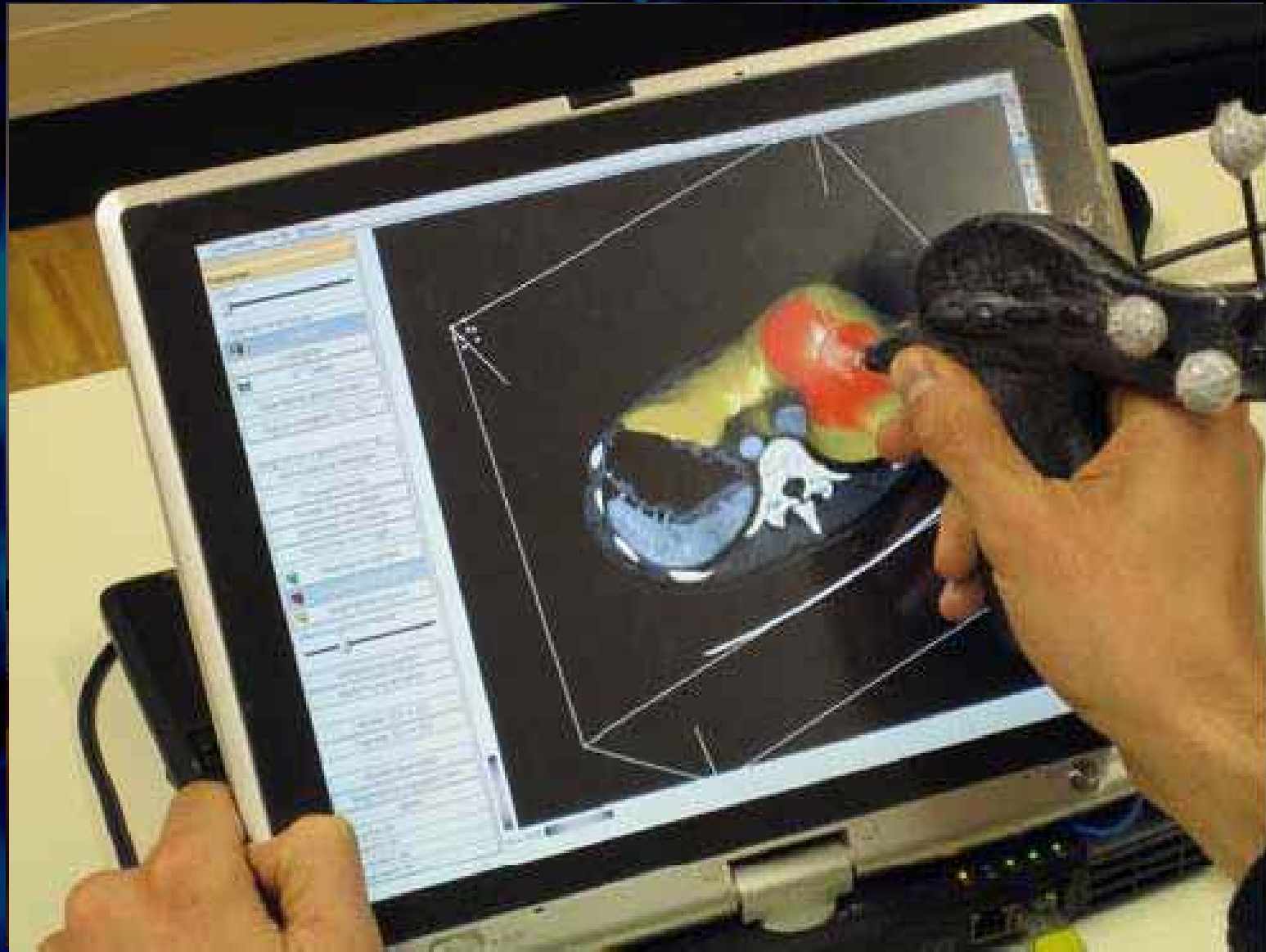
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# ***Augmented Reality (AR)***



# Virtual Planning - Idea



Computer Vision

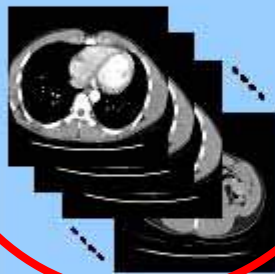
Computer Graphics

Virtual Surgical Planning



# Liver Surgery Planning System

CT Volume Data



Medical Image Analysis System (Segmentation)

Liver

Liver Vessels

Tumor(s)

Liver Segments

Augmented Reality System

Quality Assessment and Editing

Visual Inspection

Interactive Segmentation Refinement

Model Based Representation of Objects

Resection Planning

Visualization

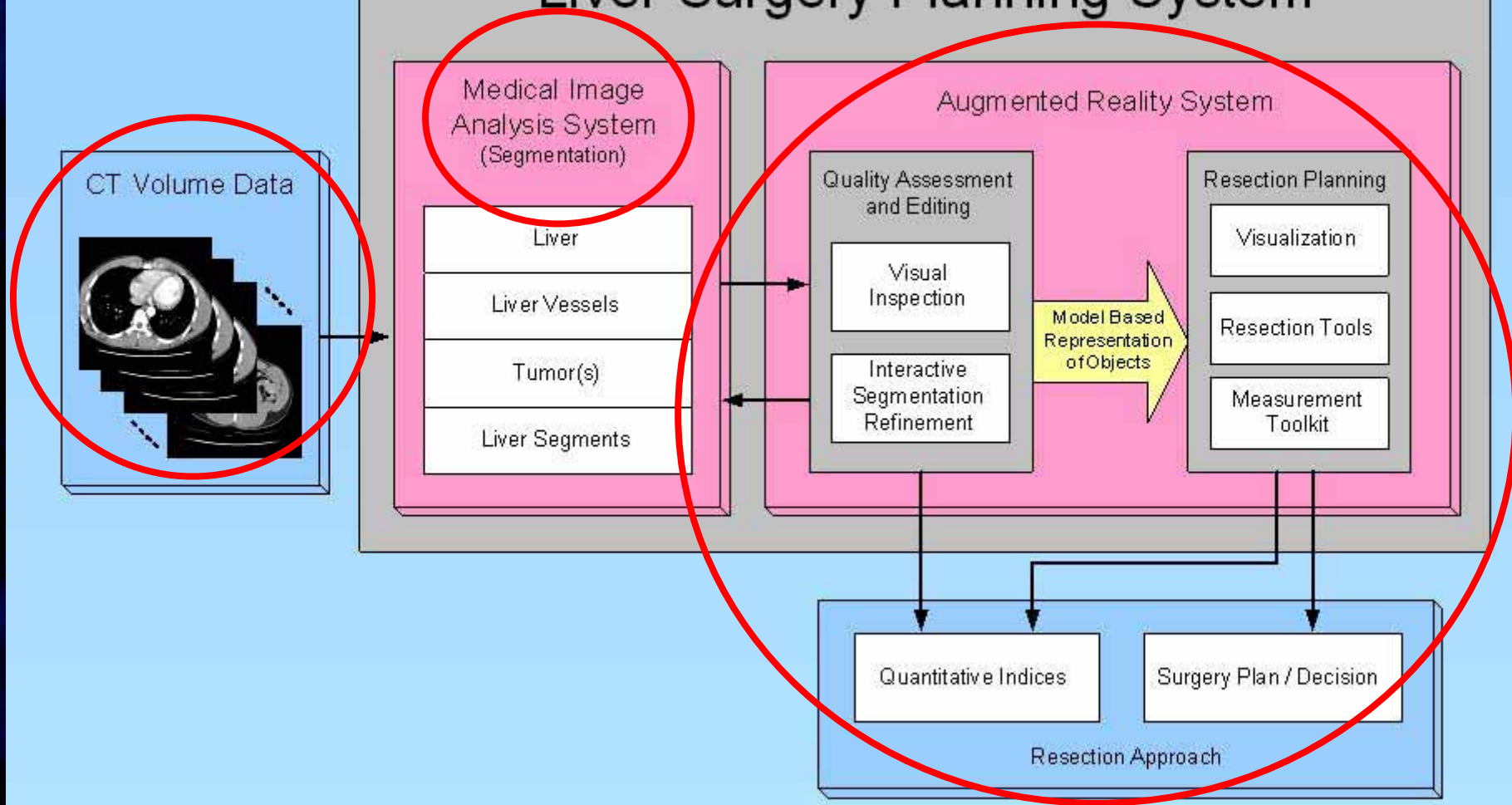
Resection Tools

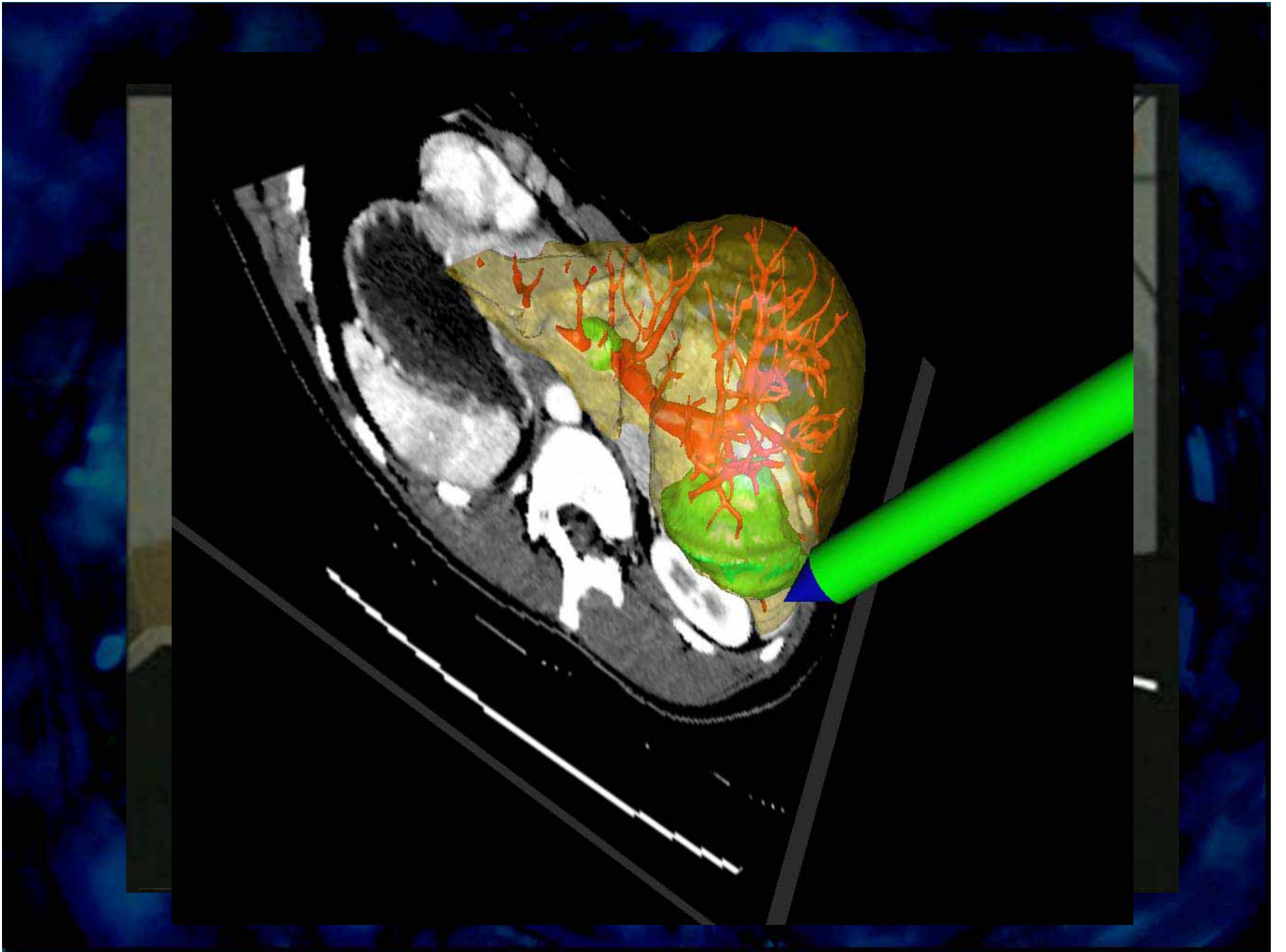
Measurement Toolkit

Quantitative Indices

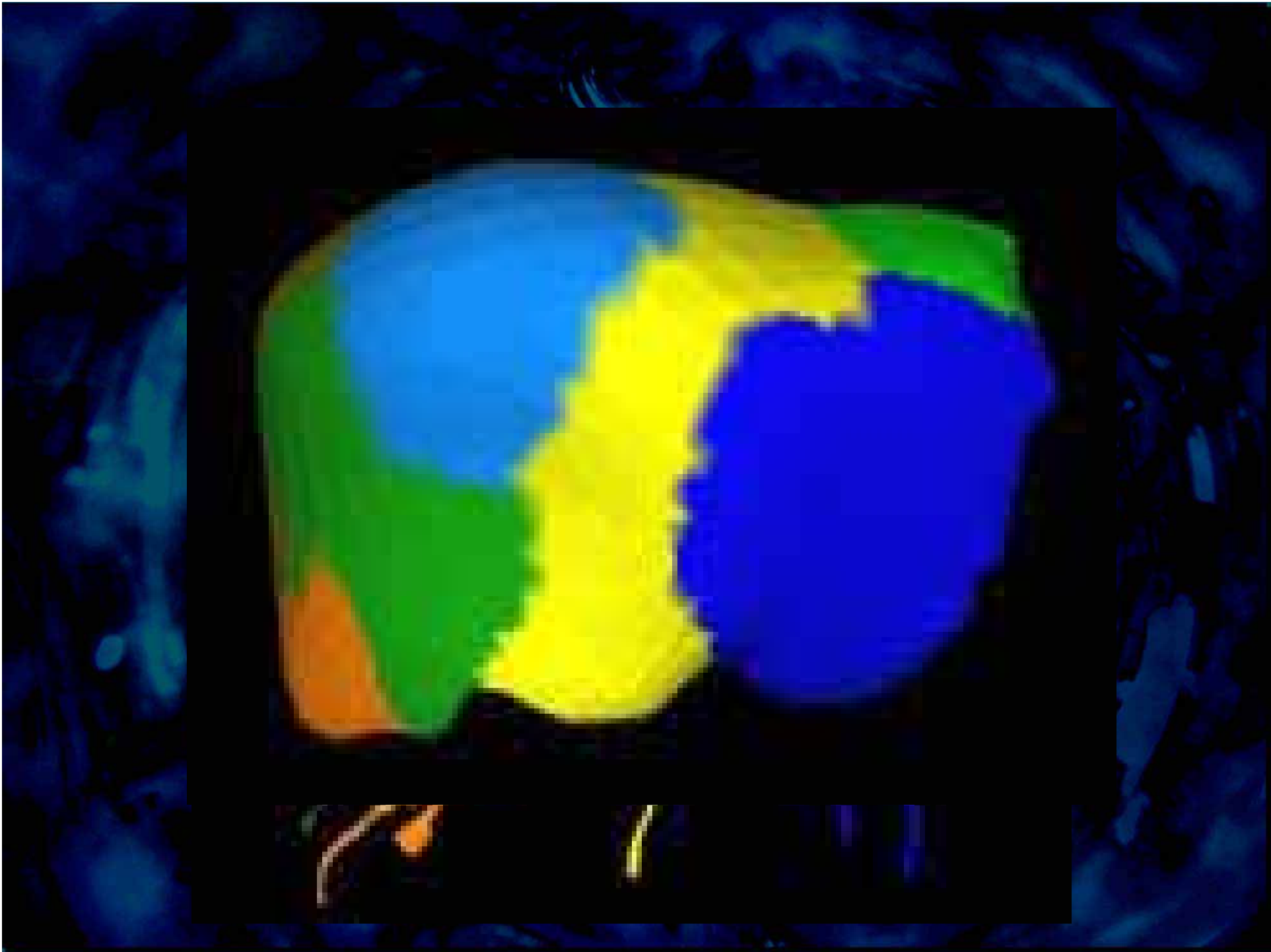
Surgery Plan / Decision

Resection Approach





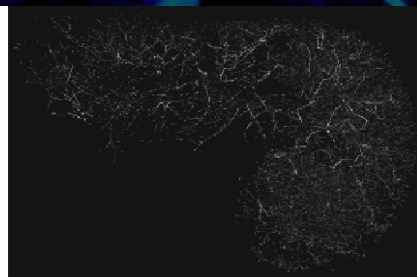




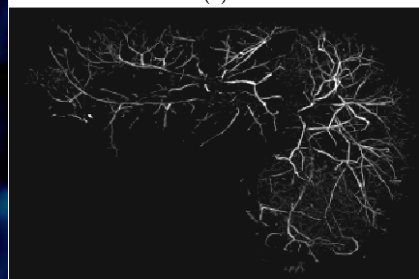
# ***Tube Detection Filter***



(1)



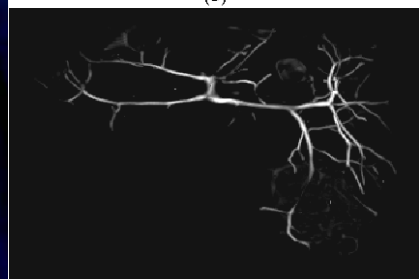
(2)



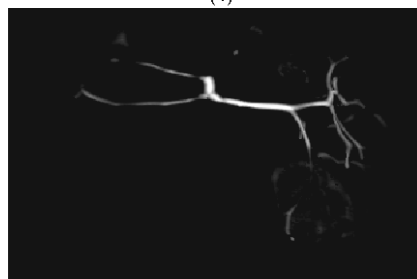
(3)



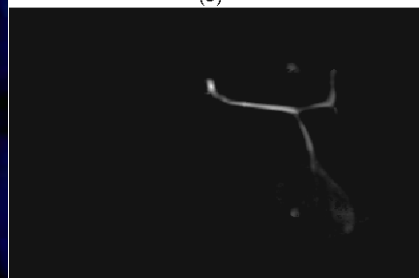
(4)



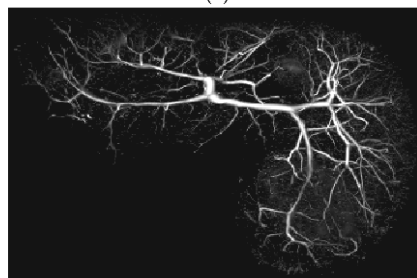
(5)



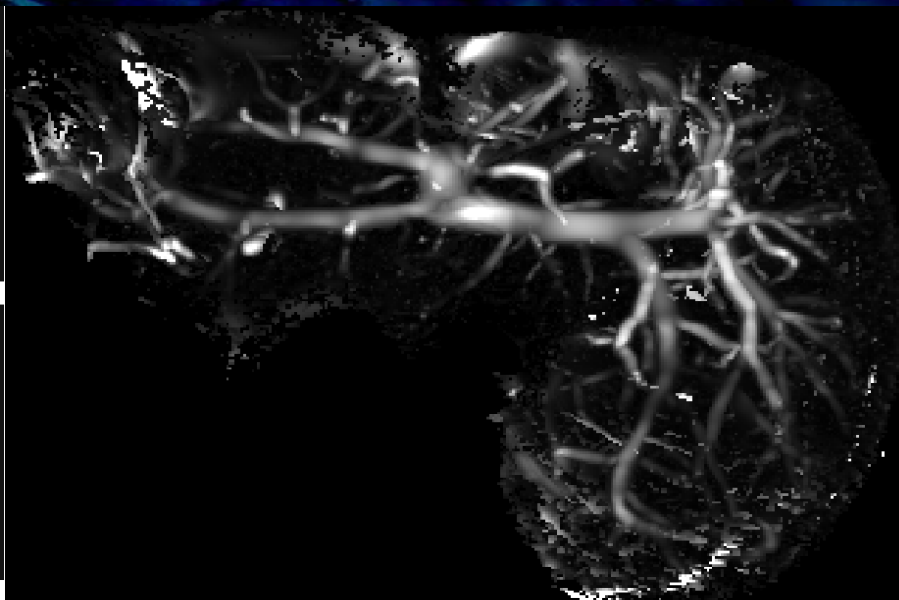
(6)



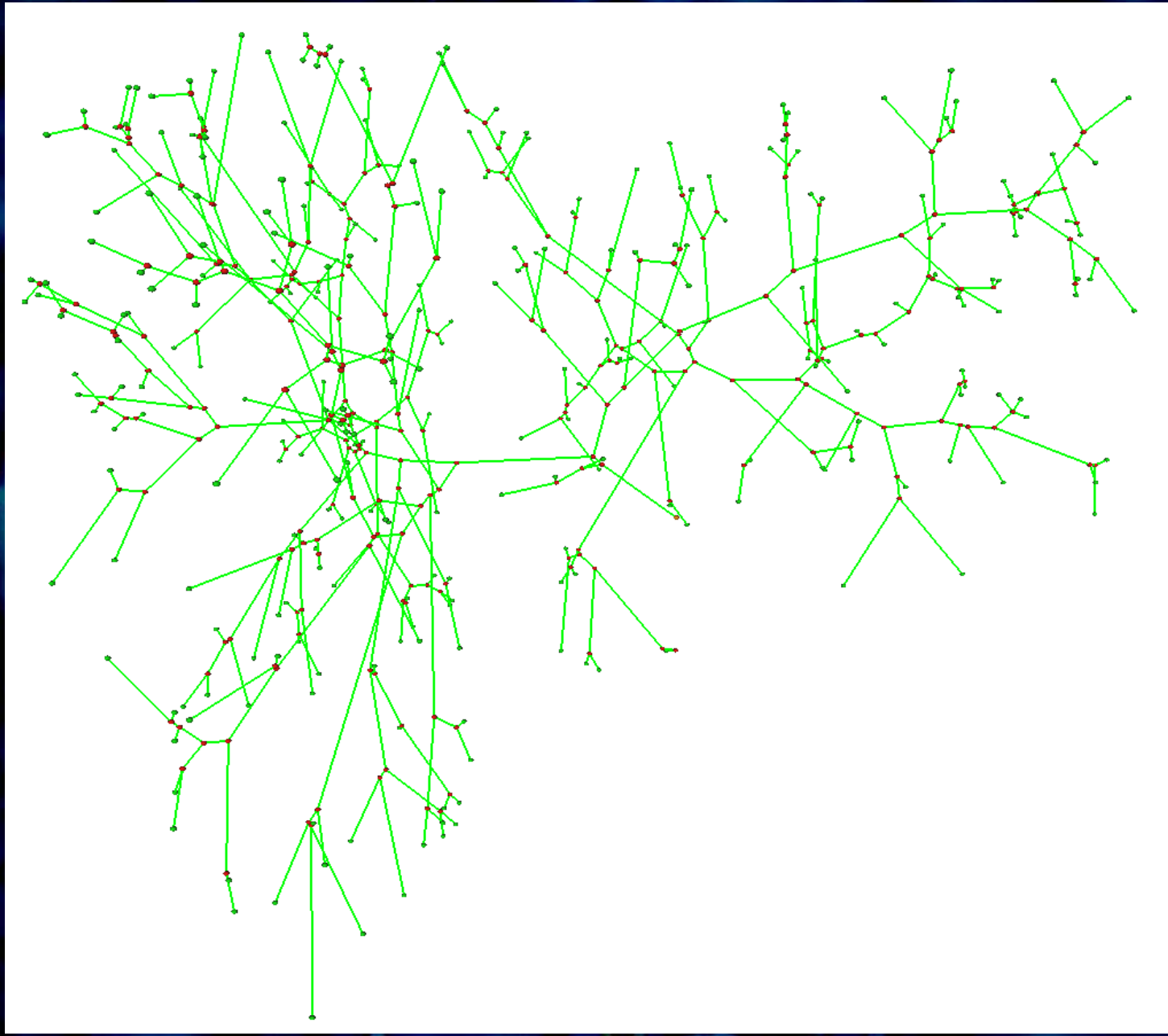
(7)



(8)



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# ***AR – Advantage?***

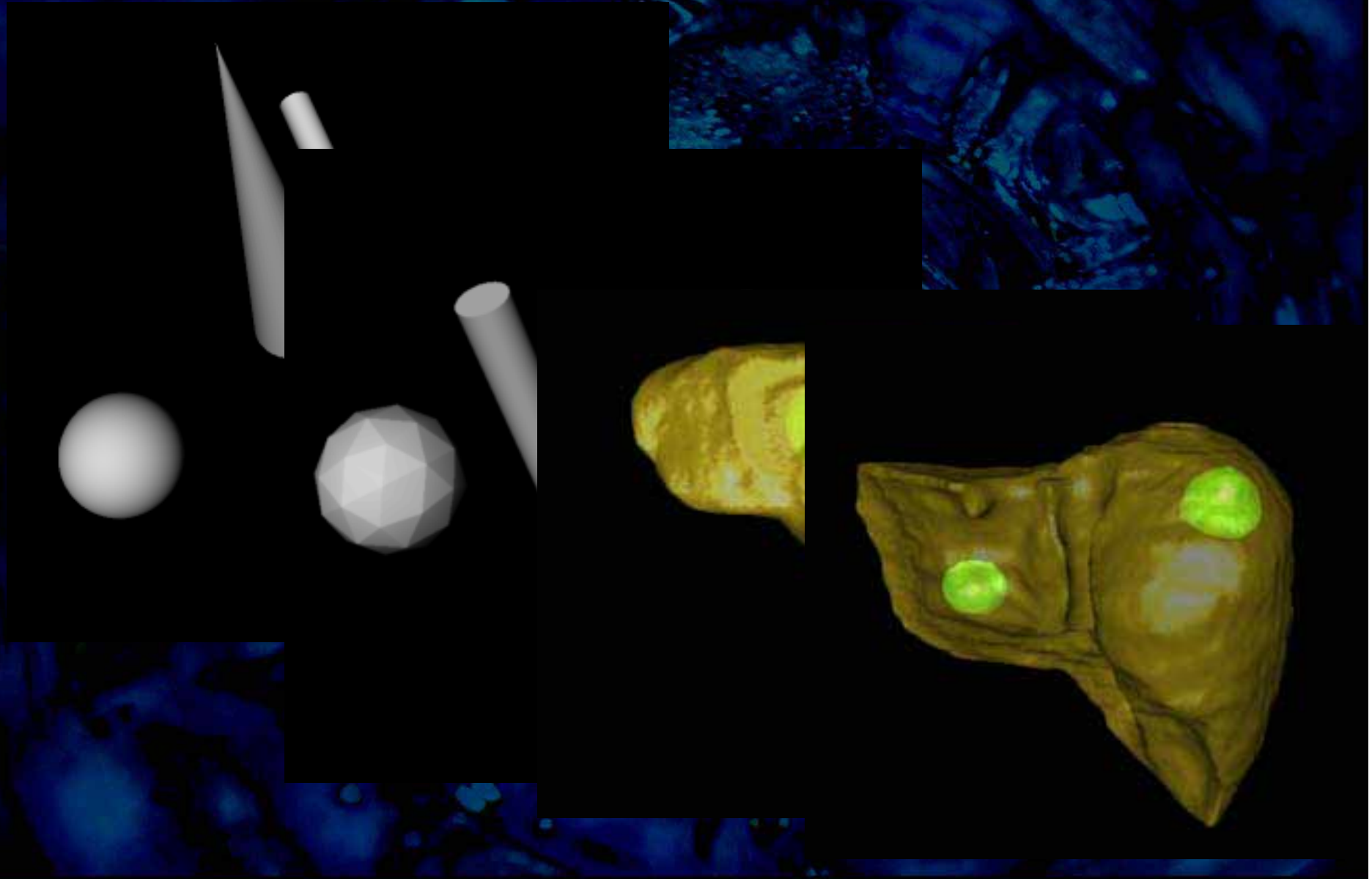
## **14 test cases:**

- Artificial objects:
  - ✓ Segmented livers, tumors
  - ✓ Portal trees

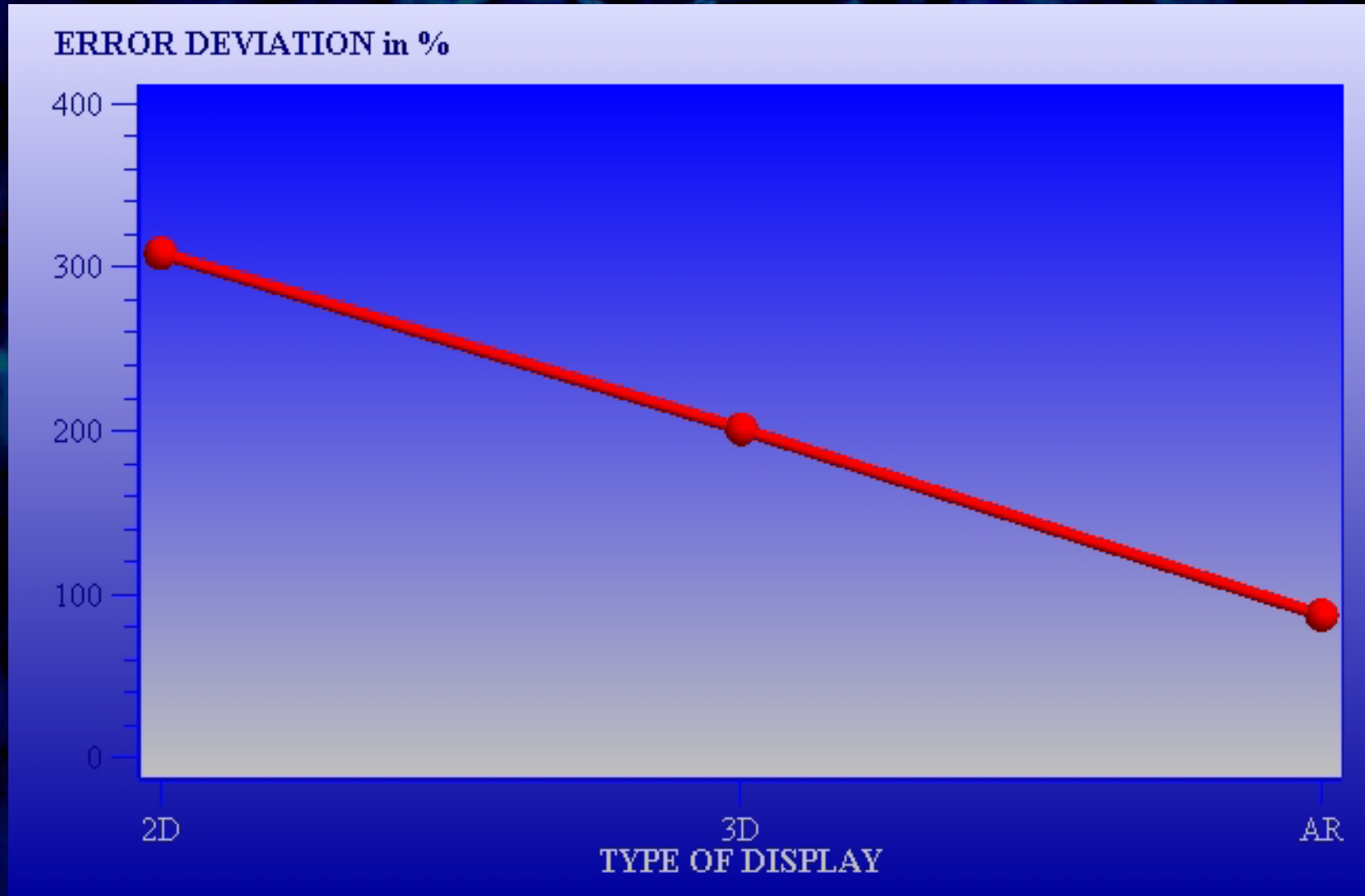
## **Tasks:**

- Volume estimations
- Volume measurements
- Distance measurements
- Evaluation systems
  - ✓ TIANI J-Vision (2D, 3D)
  - ✓ Liverplanner (AR)

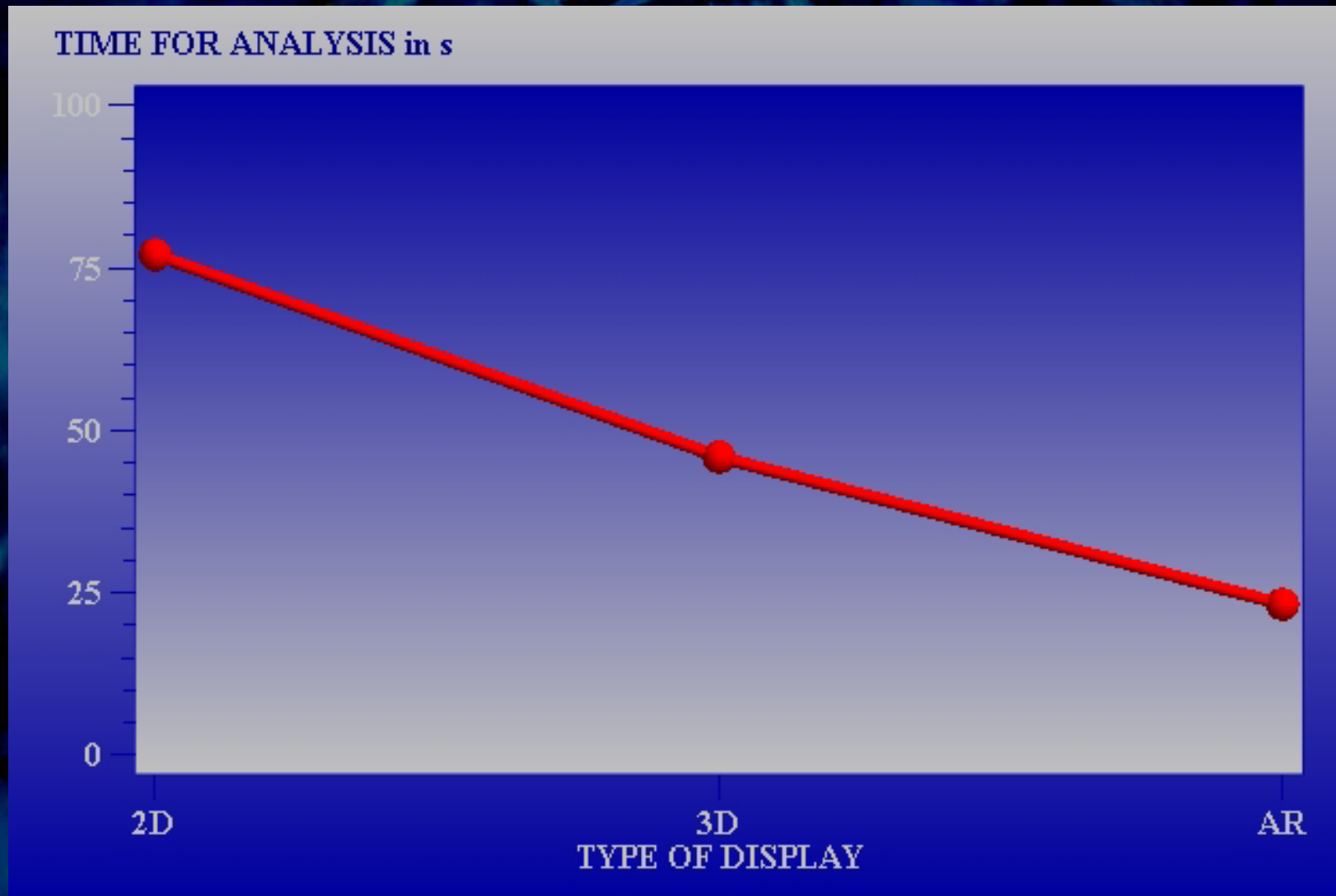
# *AR - Test Cases*



# *AR – Test → Results*

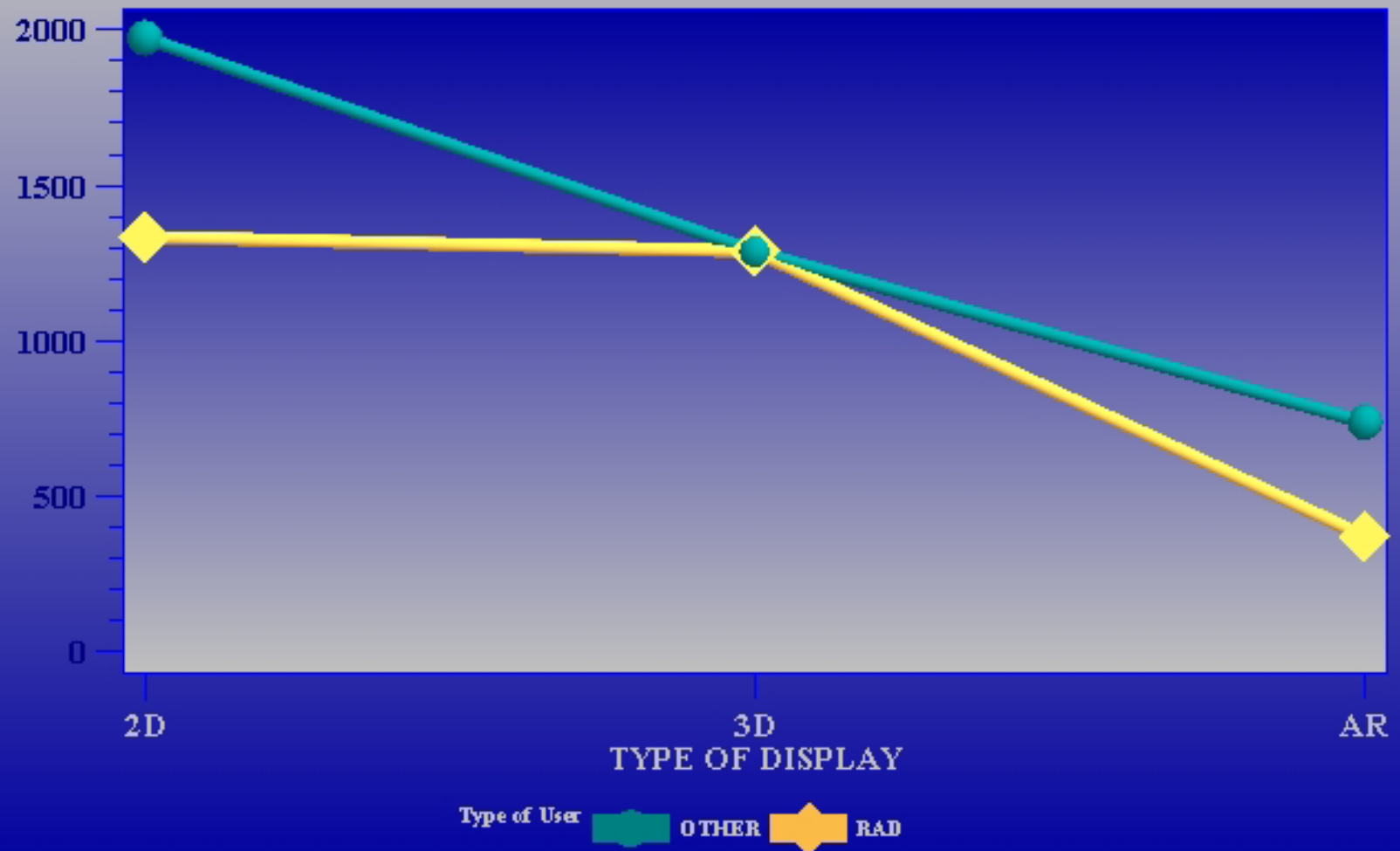


# *AR – Test → Results*



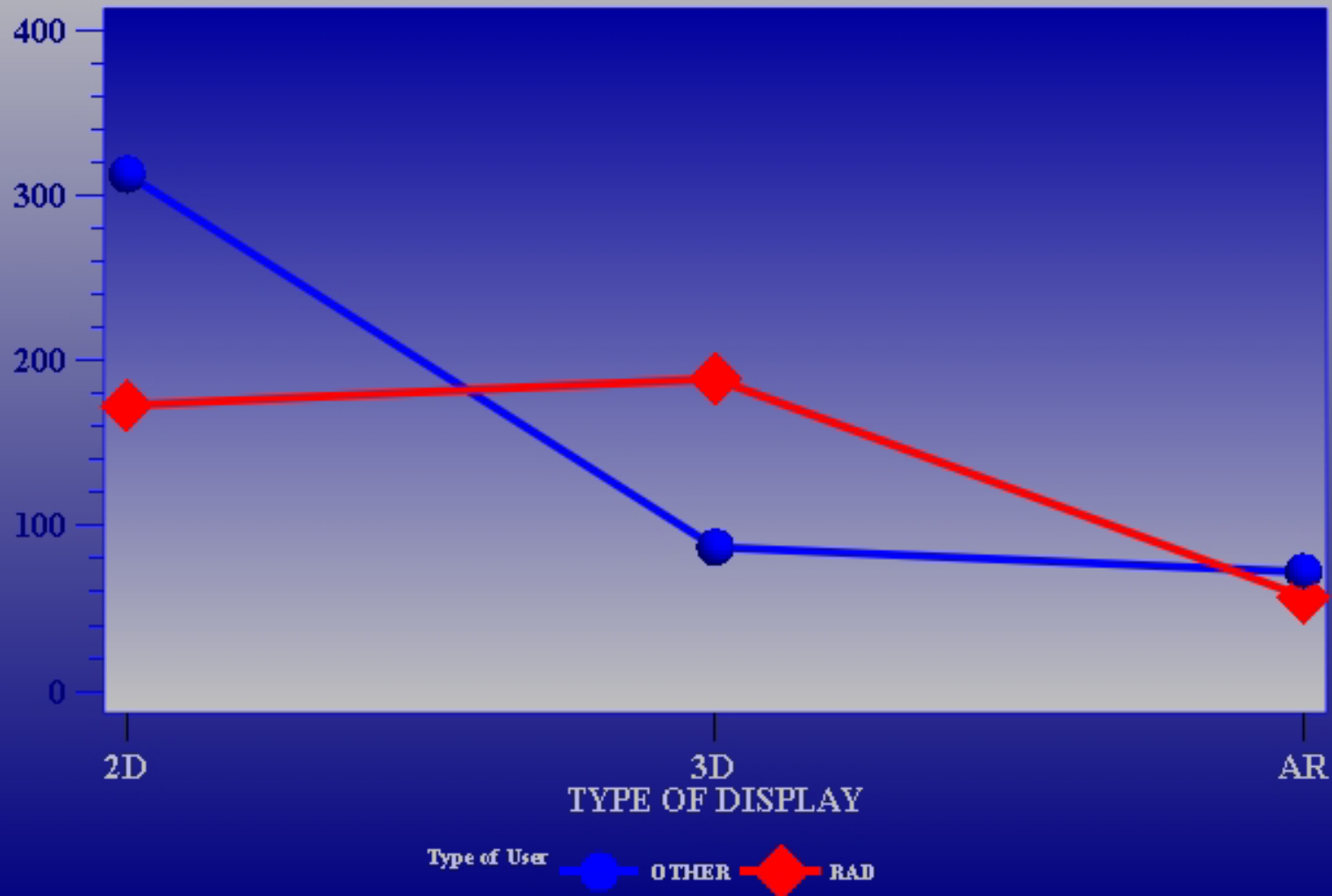
# *AR – Test → Results*

RANGE OF ERROR DEVIATION in %



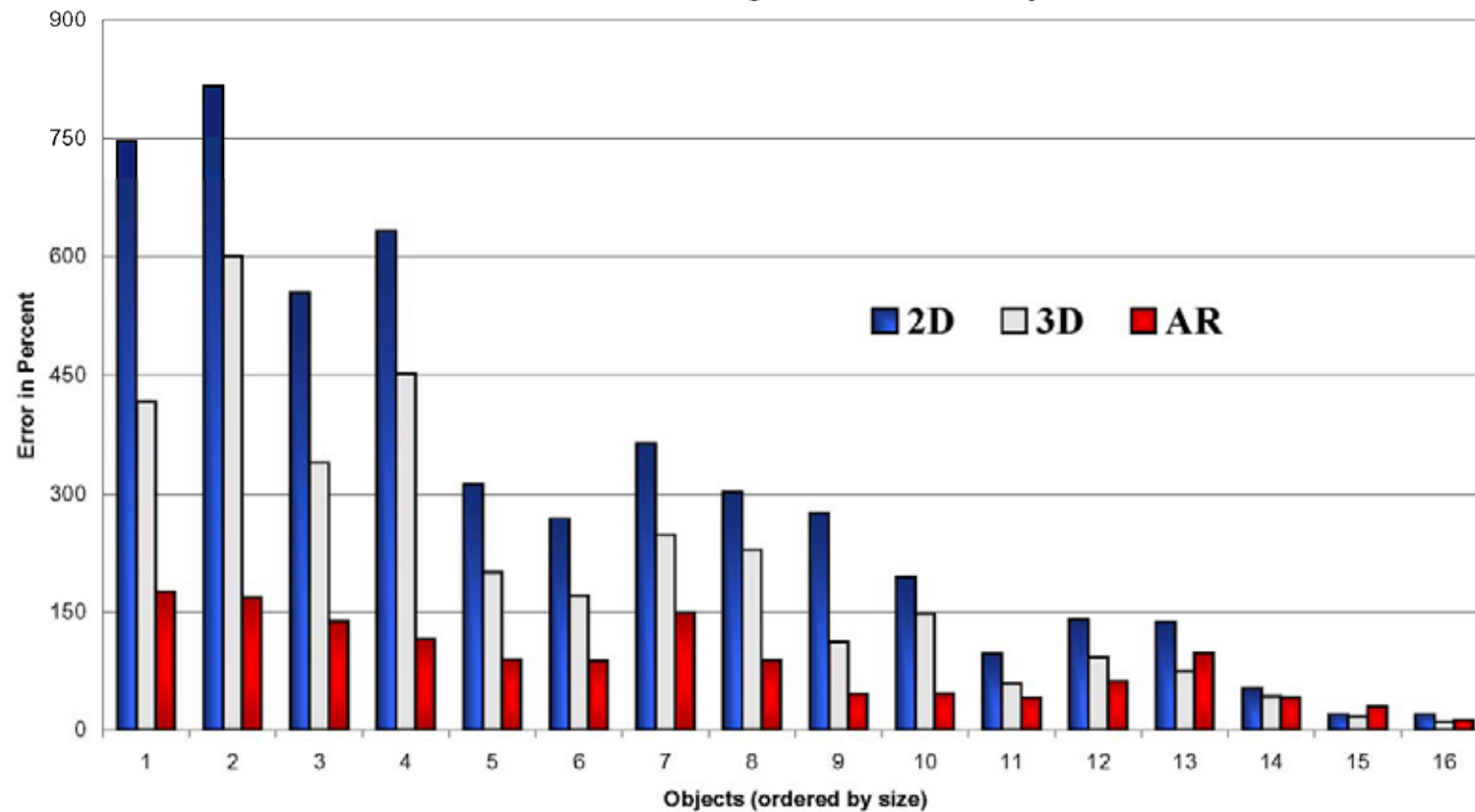
# *AR – Test → Results*

RANGE OF TIME FOR ANALYSIS IN s



# *AR – Test → Results*

**Volume Estimations**  
2D, 3D & "Augmented Reality"



# *AR – Test → Results*

## *ANOVA – Volume Error*

<u>Effect</u>	<u>DF</u>	<u>DF</u>	<u>F-Value</u>	<u>Pr &gt; F</u>
☑ Display	2	456	58.22	<.0001
☑ User	1	456	1.98	0.1596
☑ org. size	1	14	4.82	0.0455
☑ Display*User	2	456	1.57	0.2100
☑ Org. size*Display	2	4	569.13	0.0001
☑ org. size*user	1	456	0.29	0.5881

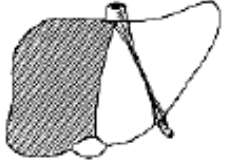
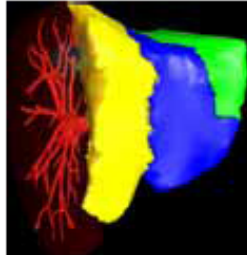
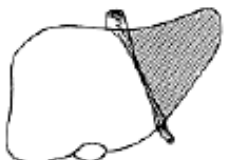
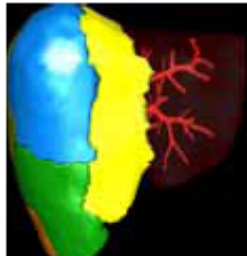
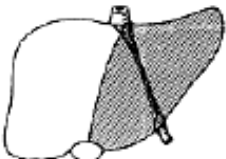
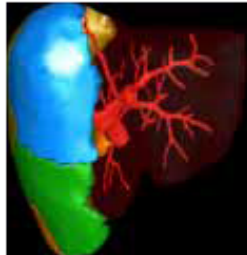


# *AR – Test → Results*

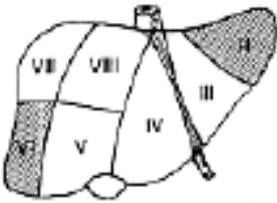
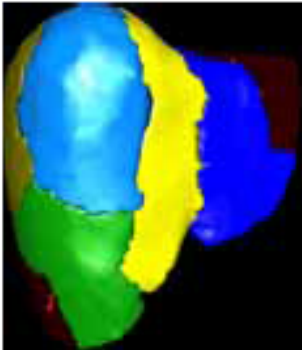
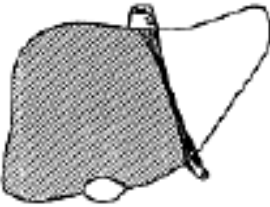
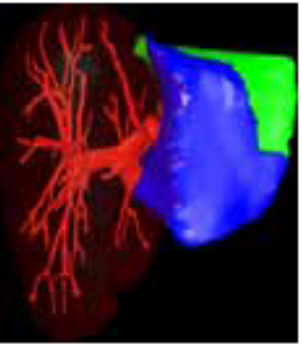
## *ANOVA – Time*

<u>Effect</u>	<u>DF</u>	<u>DF</u>	<u>F</u>	<u>Value</u>	<u>Pr &gt; F</u>
<input checked="" type="checkbox"/> Display		2	352	95.92	<b>&lt;.0001</b>
<input checked="" type="checkbox"/> User	1	352	1.24		0.2663
<input checked="" type="checkbox"/> Display*User	2	352	1.86		0.1579
<input checked="" type="checkbox"/> User*Szene	28	352	1.58		<b>0.0333</b>
<input checked="" type="checkbox"/> Org. size*user0 . . .					

# *AR: Tools for Interaction*

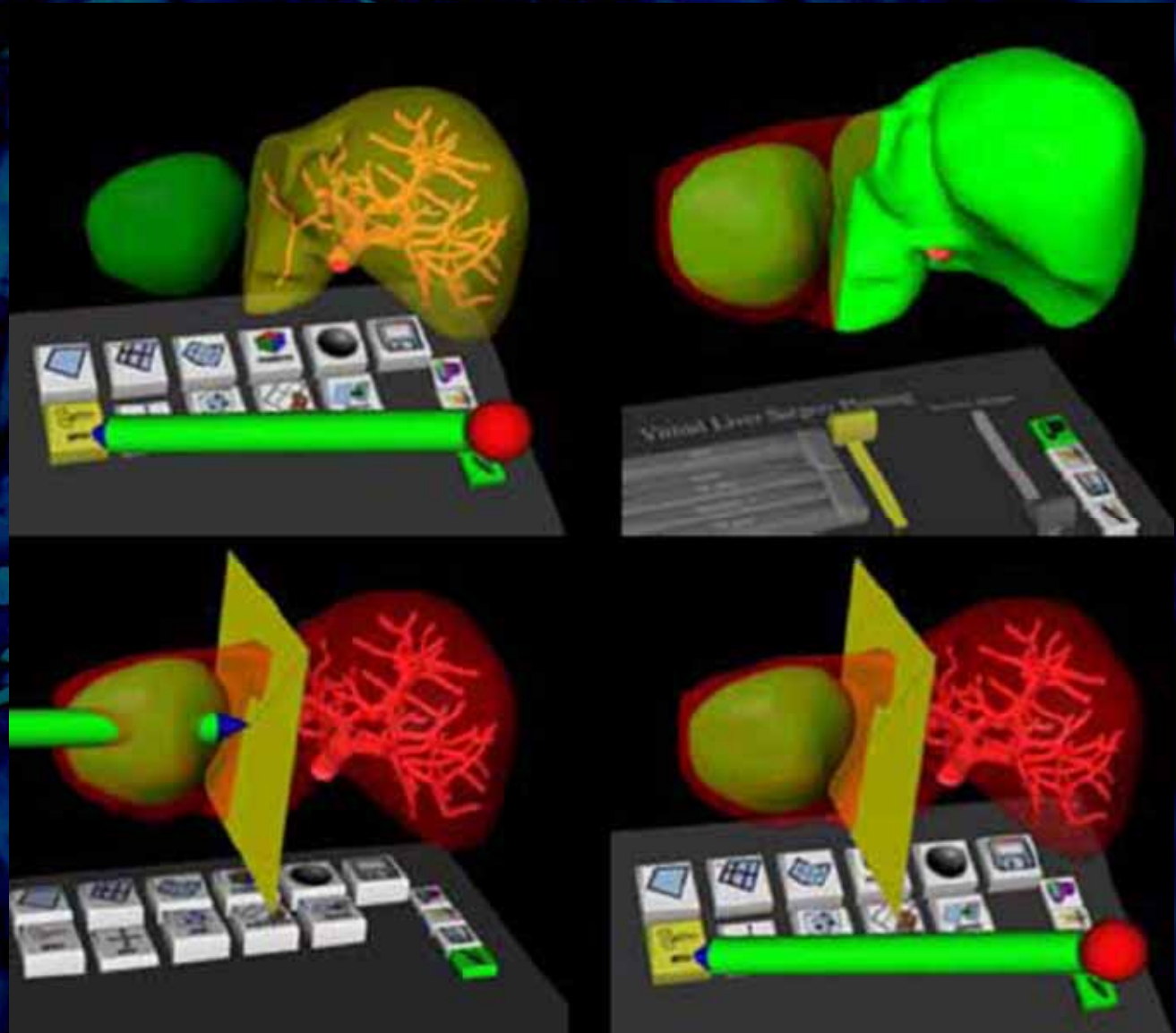
Application	Simulation	Description
 <p>right-sided hemihepatec- tomy</p>		In case of a right-sided hemihepatectomy, segment V, VI, VII, and VIII are removed.
 <p>resection of left liver lobe</p>		In case of the resection of the left liver lobe, only segment II and III are removed.
 <p>left-sided hemi- hepatectomy</p>		In case of a left-sided hemihepatectomy, segment IV is removed in addition to segment II and III.

# AR: Tools for Interaction

 <p>anatomical resection</p>		<p>If more than one tumor must be resected, specific liver segments are removed. In this particular case, segment II and VI are target for resection.</p>
 <p>extended right-sided hemihepatec- tomy</p>		<p>An extended right-sided hemihepatectomy is required if a larger tumor is located in the right liver lobe, which means that segment IV must also be removed with segment V, VI, VII, and VIII. Only if segment II and III provide enough liver function, this type of resection can be carried out.</p>

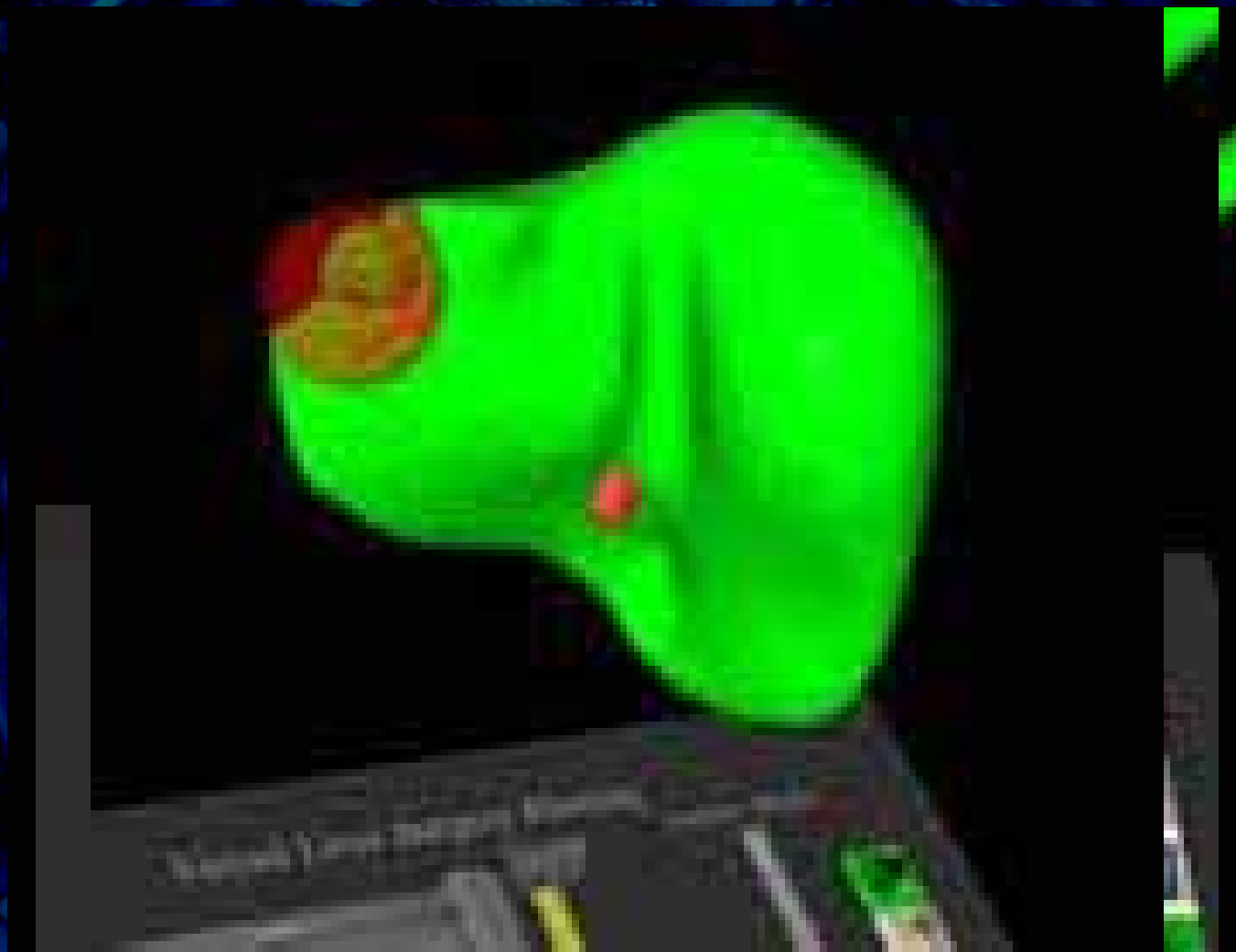
# ***AR: Tools for Interaction***

- ✓ **Resektion**  
**Tools:**
  - Hemihepat-  
ectomie



# ***AR: Tools for Interaction***

**Wedge  
Resection**



# *AR: Operation Planning*

## Information about d048

# of tumors	1
Volume of liver	1,376 ml
Volume of tumor(s)	177 ml
Initial # of tetrehedra	95k
Final # of tetrehedra	115k
Proposal, resected segments	II
Surgical decision, resected segments	atypical
Volume of resected tissue	397 ml (anatomical), 325 ml (atypical)
Volume of remaining tissue	979 ml (anatomical), 1,051 ml (atypical)
Resected tissue (in %)	29 % (anatomical), 23 % (atypical)
Time required for planning	15 min