

# **Content and Visualization:**

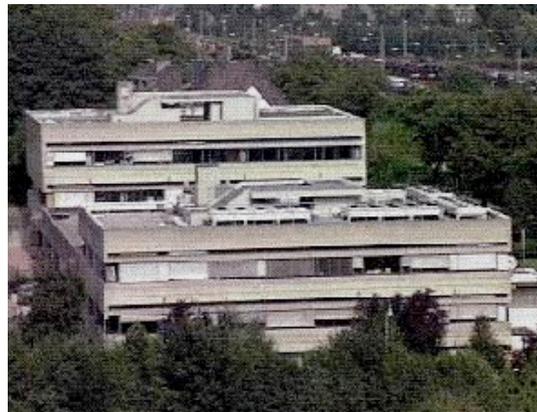
## **Selected Examples and a closer look at a Medical Simulator**

**Sebastian Ullrich**



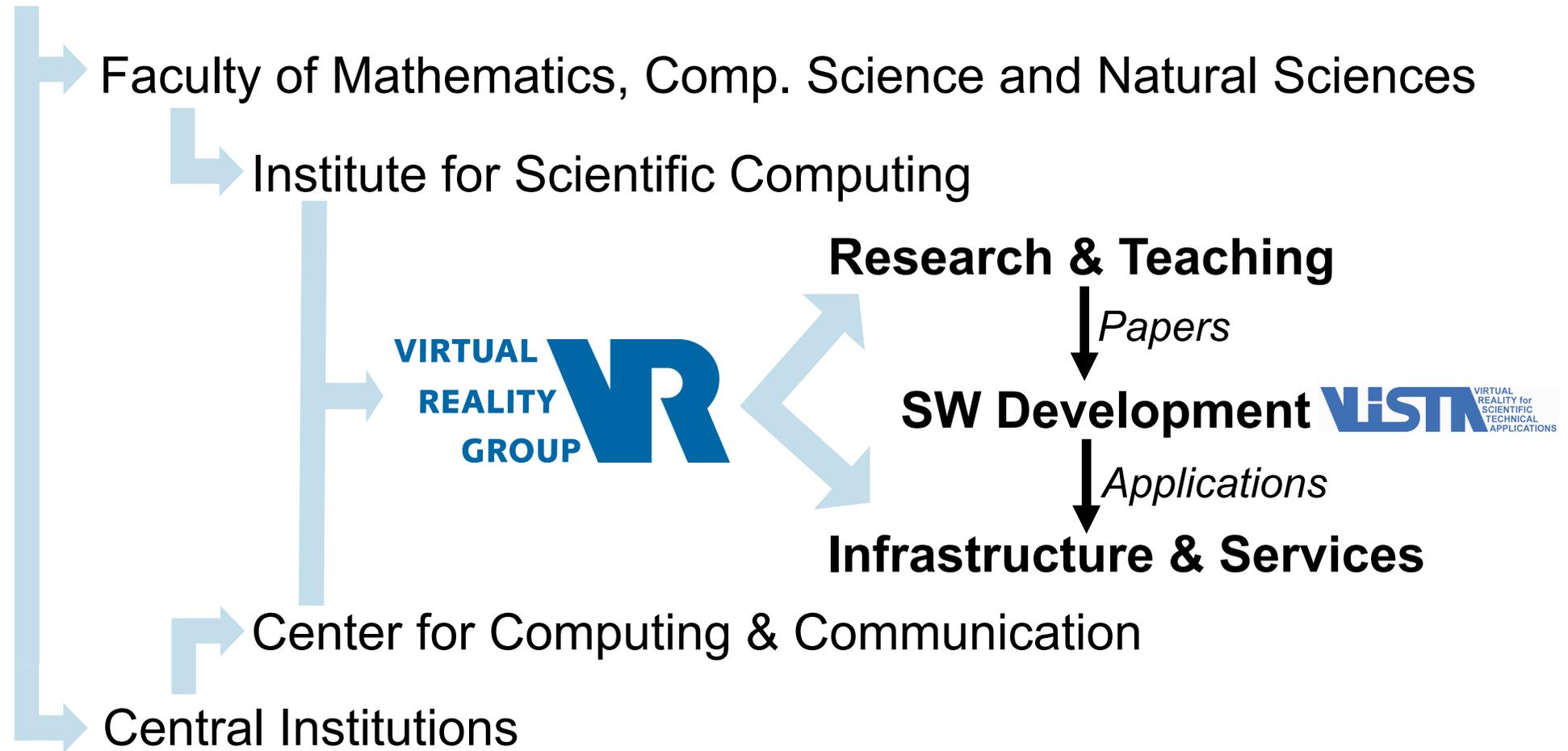
# RWTH Aachen University

- 30,000 students, 414 professors, 2,000 scientists
- 9 faculties
  - natural sciences
  - mechanical engineering
  - electrical engineering
  - civil engineering
  - mining and geology
  - architecture
  - psychology
  - economy
  - medicine



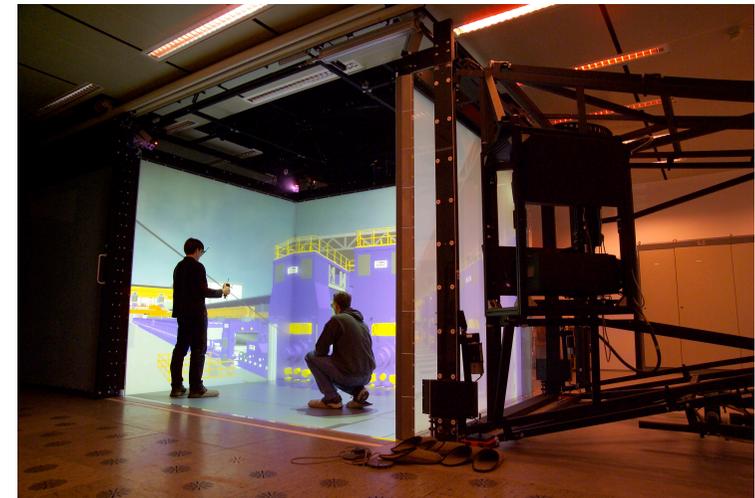
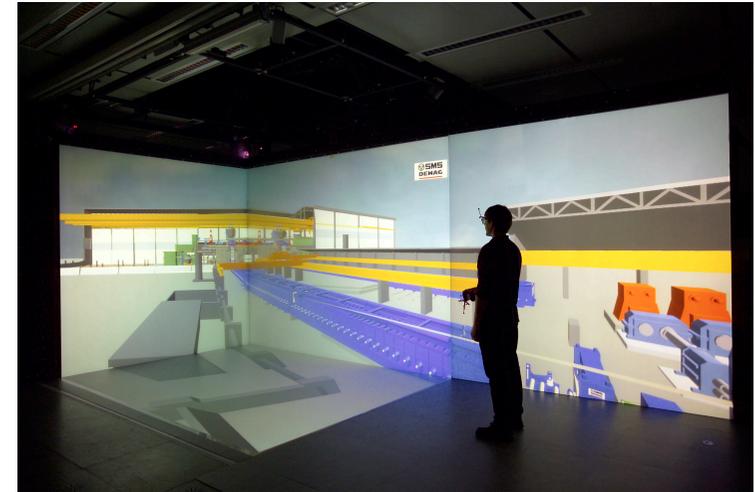
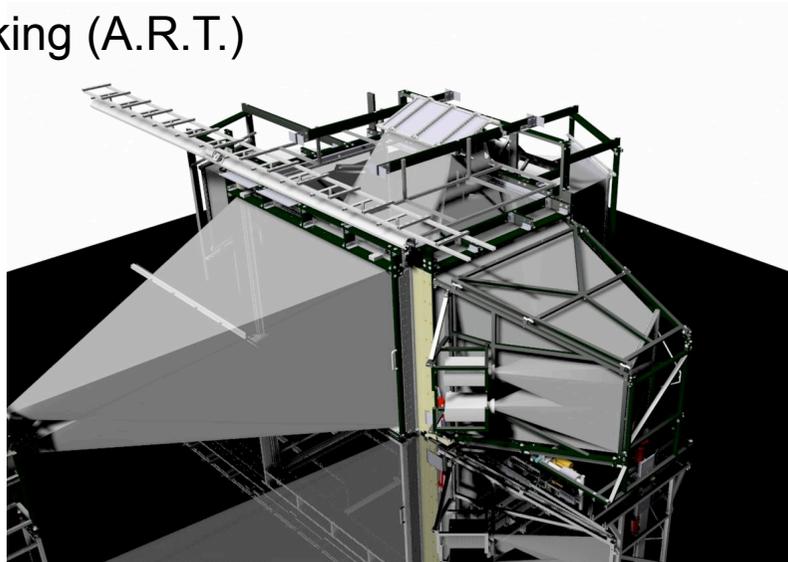
# The VR Group @ RWTH Aachen University

# RWTH



# VR Group: Infrastructure - CAVE

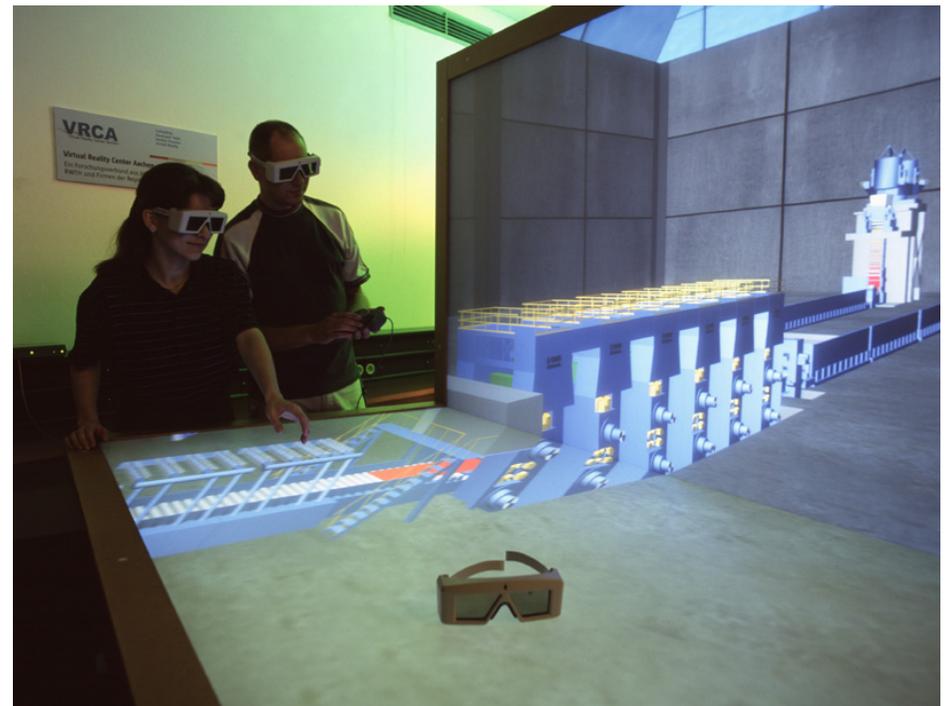
- Installed in spring 2004 by BARCO
- 3.60 x 2.70 x 2.70 m (non-quadratic!)
- 4 walls + floor (front projection)
- MoVE Module
- LCD projectors, 1600x1200 pixels
- Synchronization of colors & brightness between projectors
- Circular polarization
- Optical Tracking (A.R.T.)
- PC Cluster



# VR Group: Infrastr. - Semi-Immersion Devices



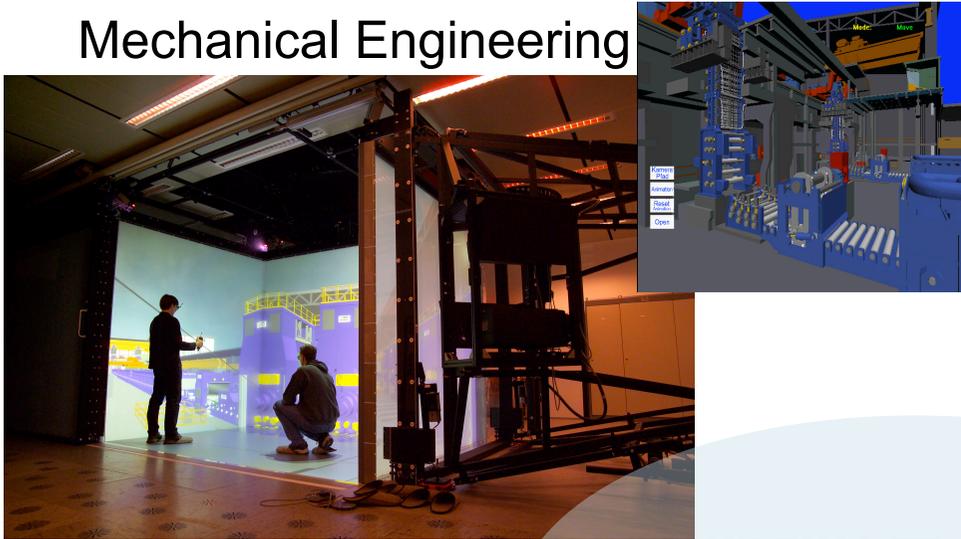
Office VR system developed by Fraunhofer IAO  
(3 installed at RWTH)



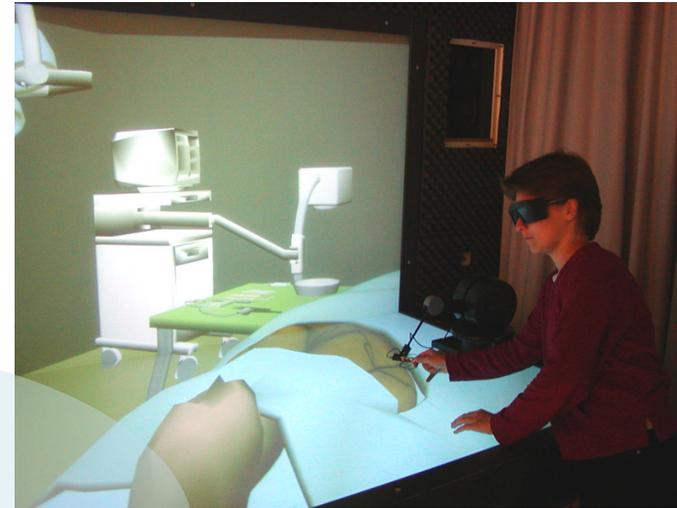
L-Bench  
(2 installed at RWTH)

# VR Group: Research & Application Fields

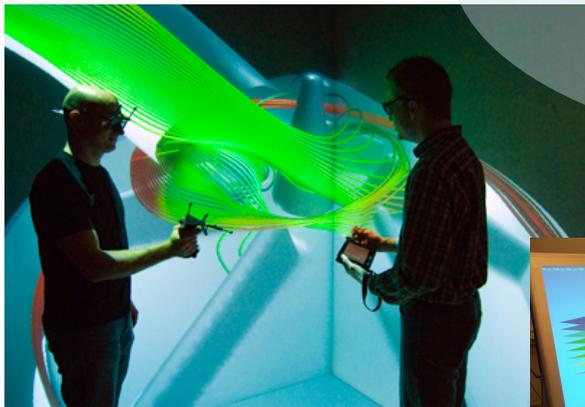
## Mechanical Engineering



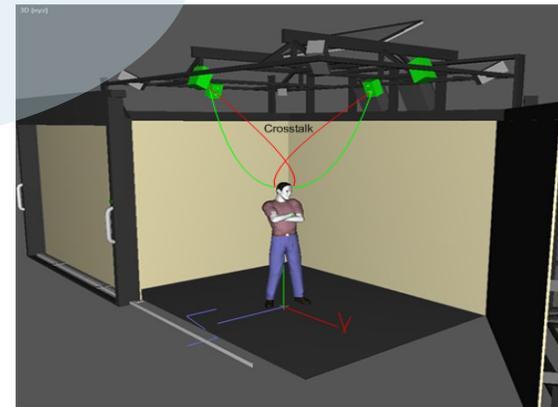
## Medicine & (Neuro-)Psychology



VIRTUAL  
REALITY  
GROUP **VR**

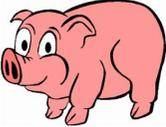


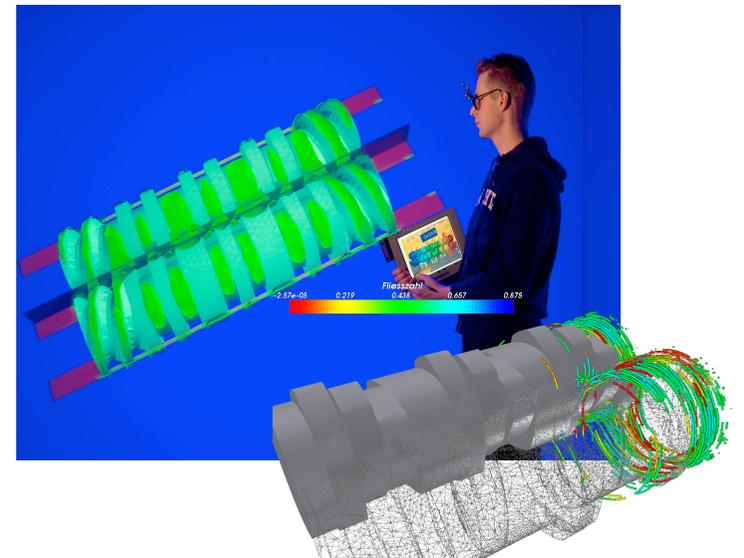
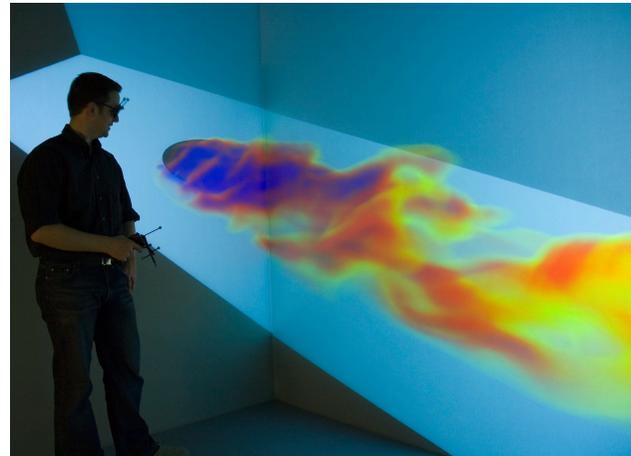
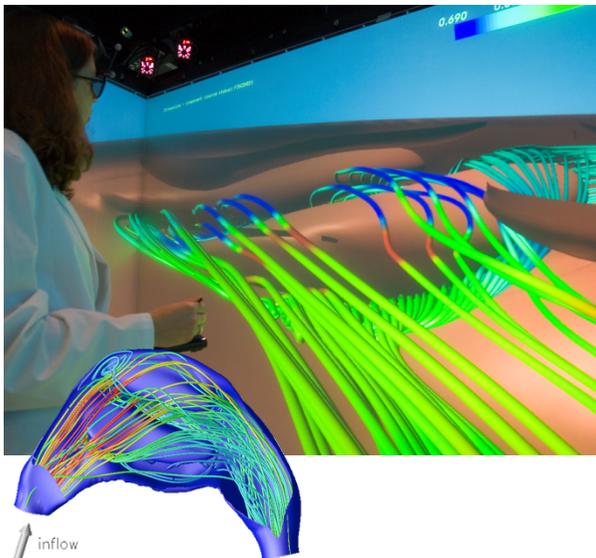
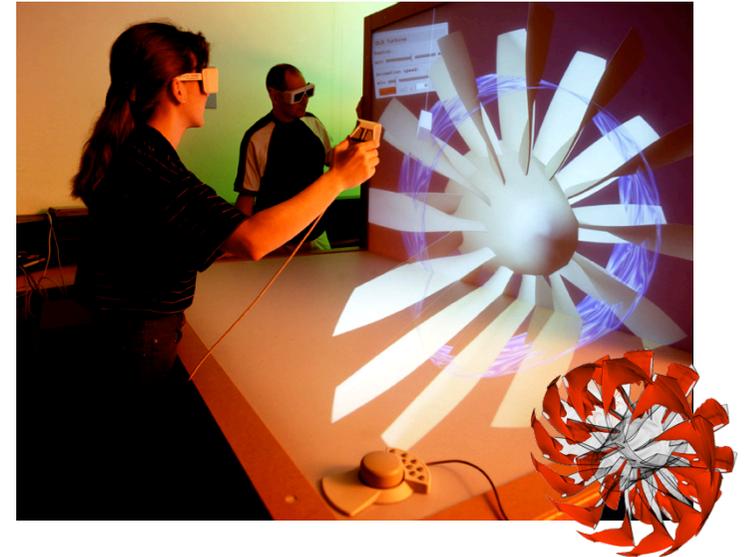
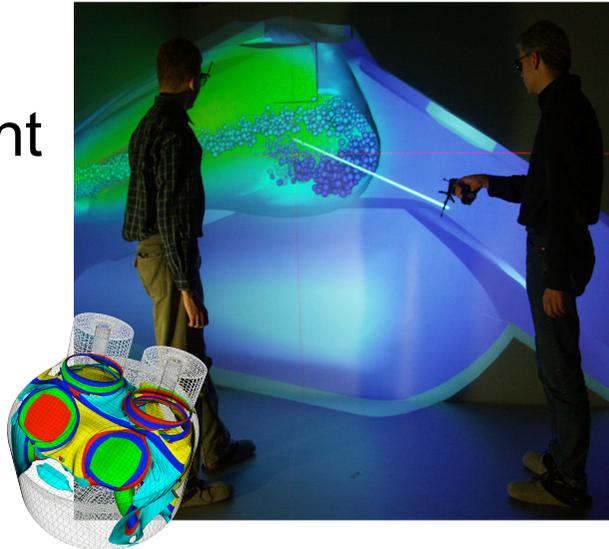
## Simulation Science



## Basic Methods

# VR Group: Applications for VRFlowVis

- Motor development
- Turbine development
- Twin extruders
- Nasal airflow
- Pig housing 
- .....



# VR/Visualization Needs a User-Centered View!

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Let the user ...

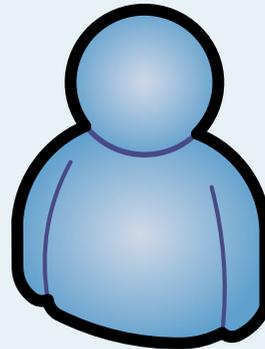
... effectively ...

... interactively ...

... efficiently ...

... conveniently ...

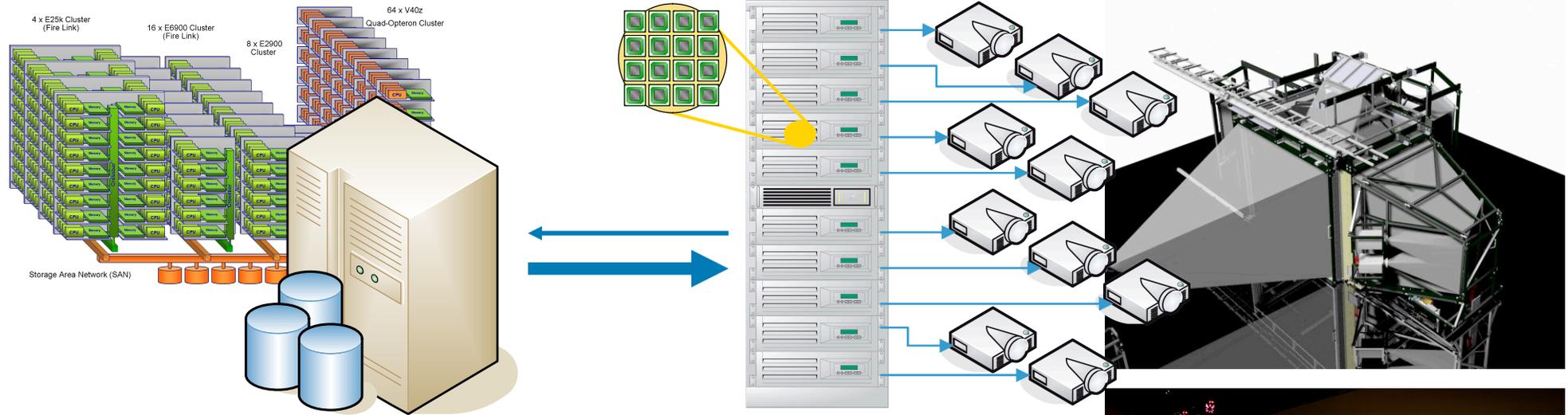
... analyze her/his data



# General Research Challenges

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- **Performance: Provide interactive response times!**
  - Latency versus overall speed up
  - User-centered parallelism, scheduling, data & task management
  - Single algorithms versus framework view
- **Interaction: Increase user acceptance!**
  - Navigation in space
  - Navigation in time
  - Creation of and interaction with vis objects in 3-D space
  - Explorative analysis of (mostly large) data



## HPC cluster/Backend

- ☺ Ultra High Performance
- ☺ Large Storage
- ☹ High Latency



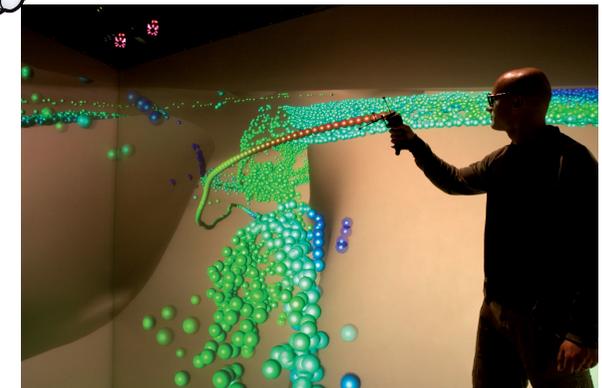
Large-Scale Data Processing  
(Low- & Mid Frequency tasks,  
e.g., iso surface extraction)

## Rendering Nodes

- ☹ Medium/High Performance
- ☹ Medium/Small Storage
- ☺ Low Latency/Real-Time



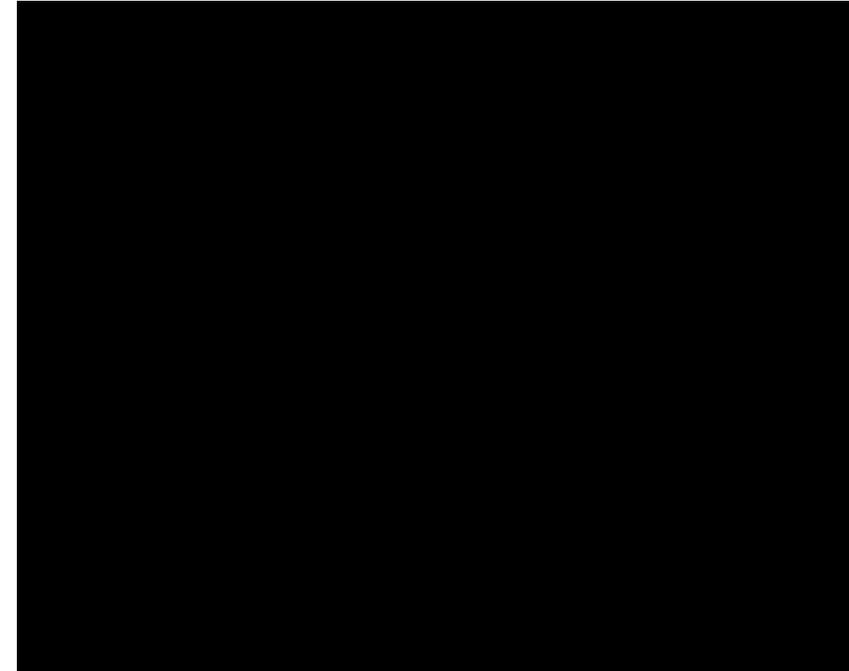
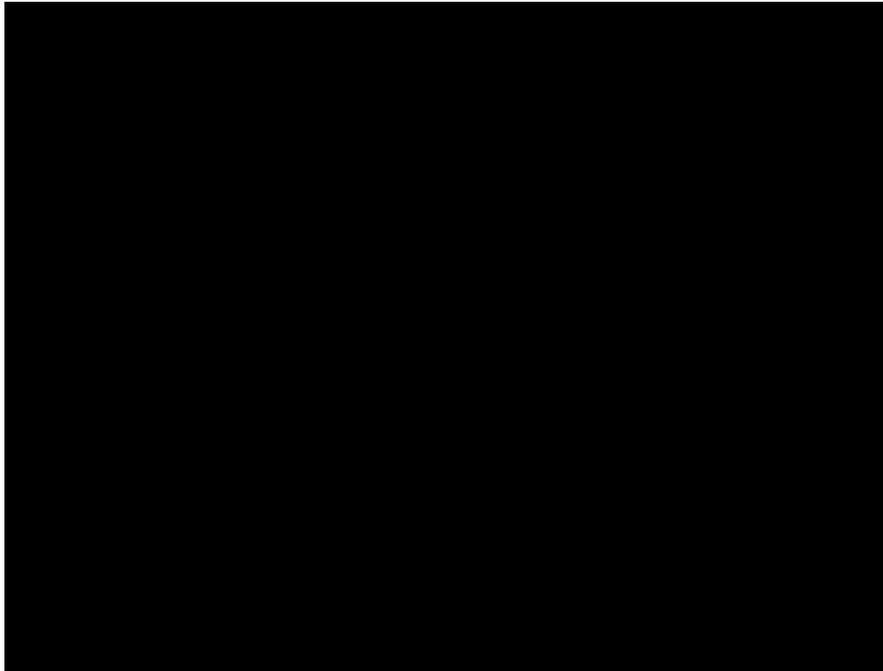
Interactive Operations  
(High Frequency,  
e.g., navigation)



[IMACS 2000, SC 2004, EGVE 2003, EGPGV 2006, SC 2006, EGPGV 2007, ParCo 2007, SEARIS 2008, CGF 28(6)]

# “The Virtual Windtunnel Revisited”

Marc Schirski et al.



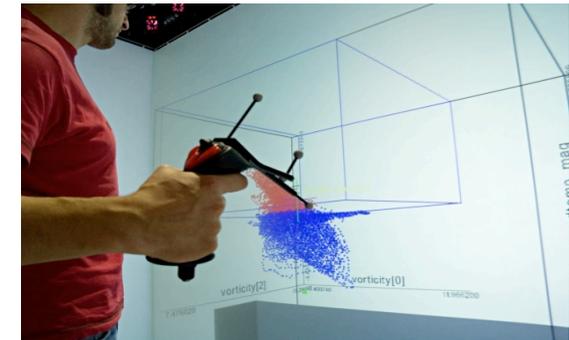
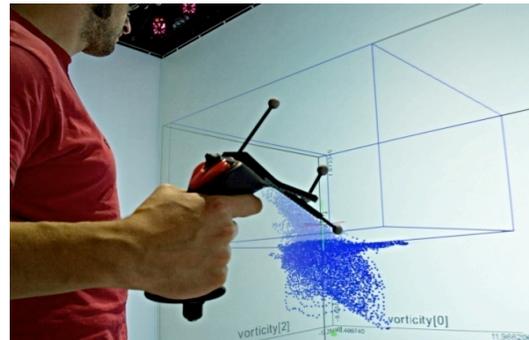
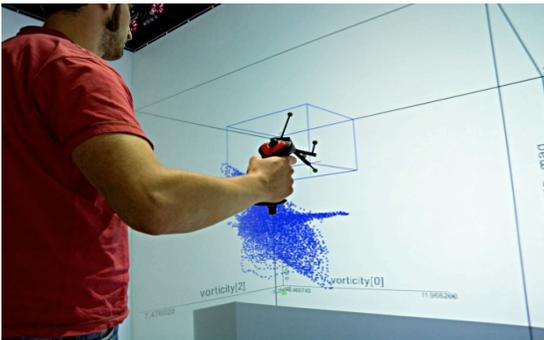
- GPU-based Real-Time Particle Tracing
- Works for structured as well as unstructured grids
- Also works for time-varying phenomena
- Optional: Regions of interest extraction on parallel backend
- Advanced Billboard Rendering (Virtual Tubelets)

[IEEE VR 2005, SIGGRAPH 2005, C&G 29(1), VMV 2006, MMVR 2007, EGVE 2007]

# Brushing and Linking in VR

Bernd Hentschel et al.

- Implement InfoVis-based feature definition in a virtual environment to enable true 3D interaction and viewing.



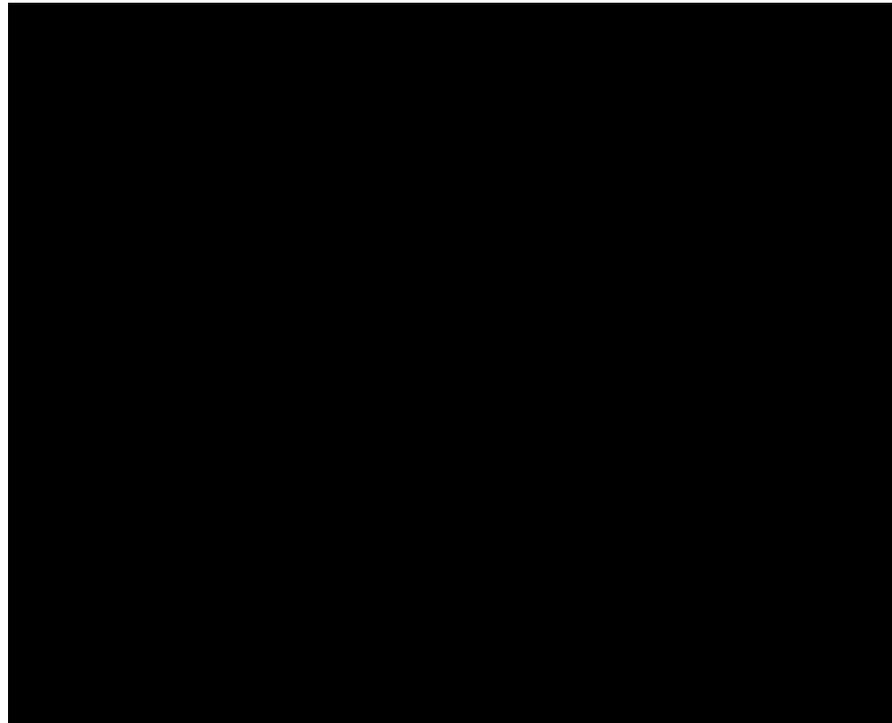
- Leverage the power of parallel computing resources in order to allow interactive work with real-world data.
- 3D scatterplots of arbitrary data attributes
- User interactively marks interesting regions
- Marked points are highlighted in all *linked views*

# Brushing and Linking in VR: Example

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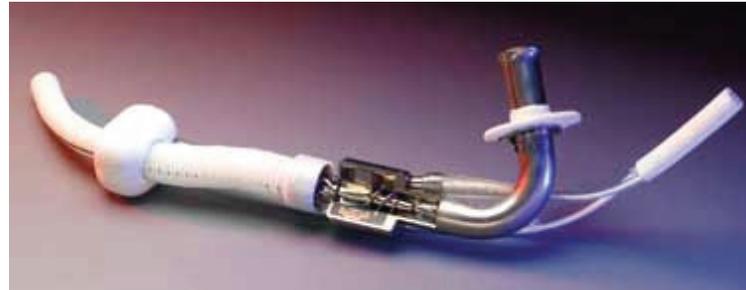
[EGPGV 2009]

- Interactive Analysis in the CAVE

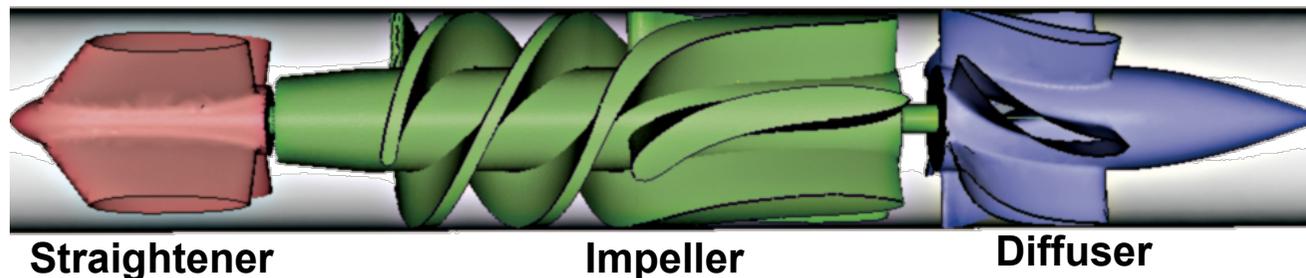


# Blood Damage in Ventricular Assist Devices

Irene Tedjo et al.

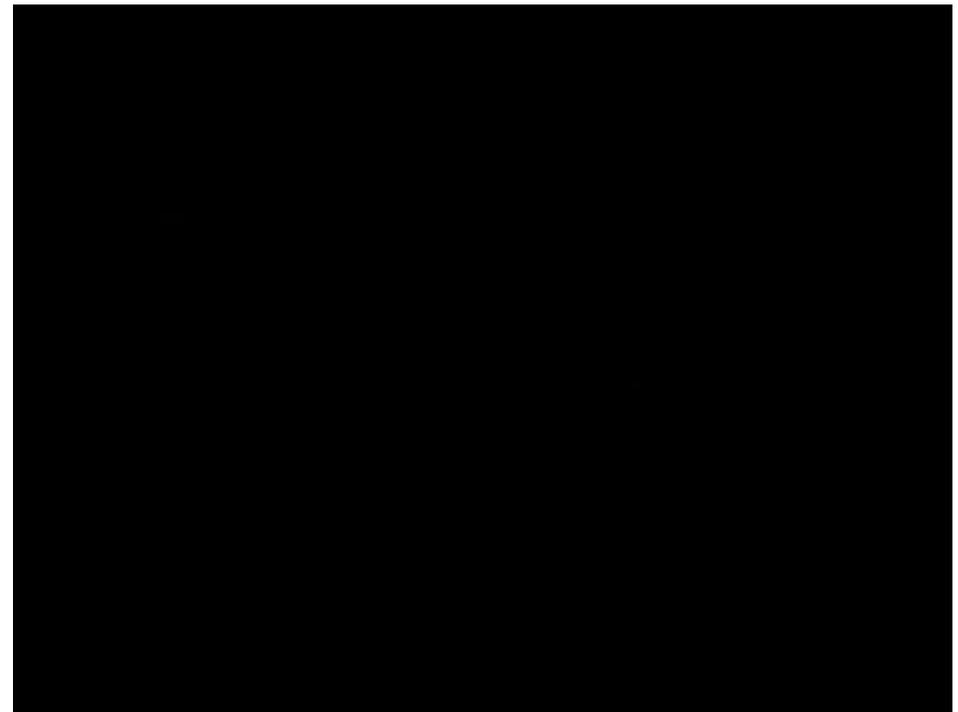
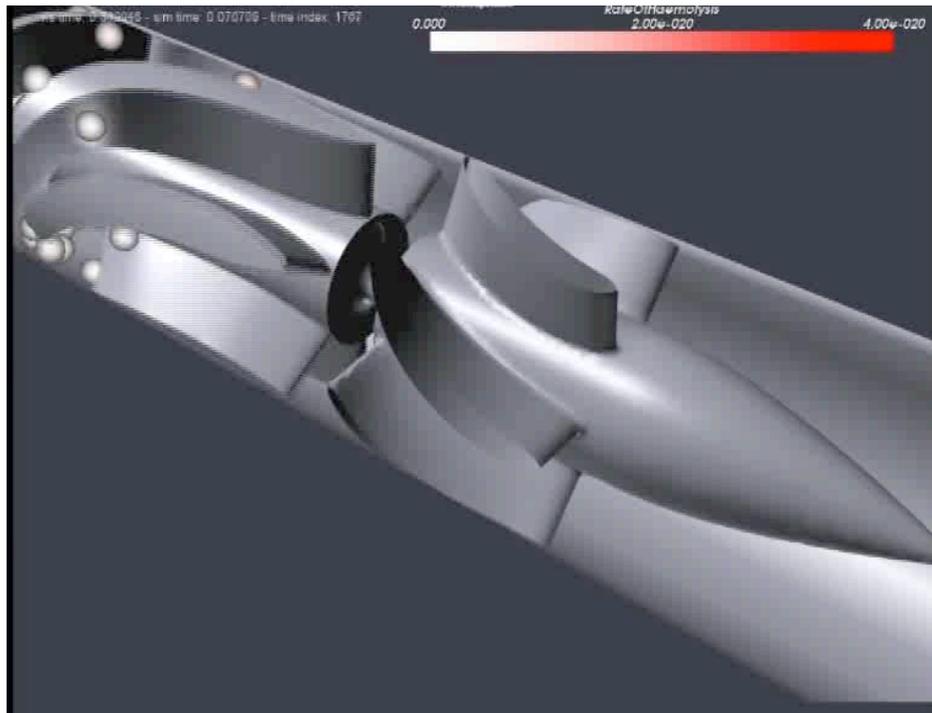


- **Long term goal:** Long time or even permanent use of VADs
- But: VADs lead to blood damage.
  - Hemoglobin „leaks“ out of red blood cells (RBCs). → **hemolysis**
  - High amount of hemolysis may lead to anemia and intoxicate kidneys.
- Therefore simulate and analyze visualizations



# Blood Damage in Ventricular Assist Devices

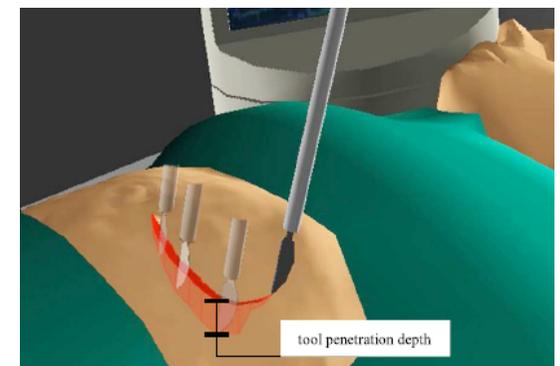
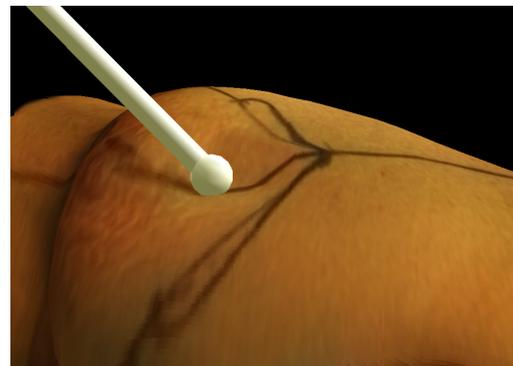
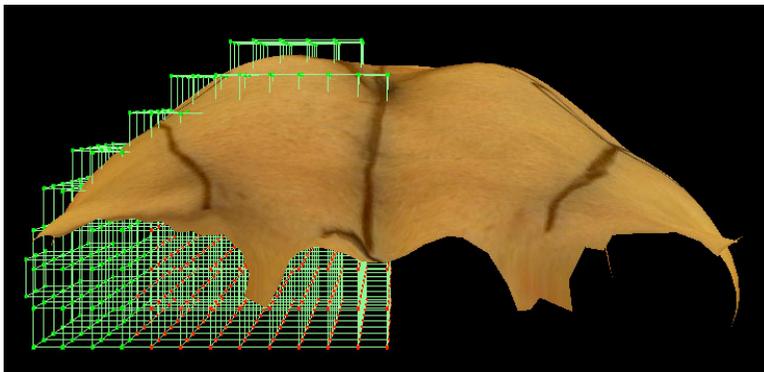
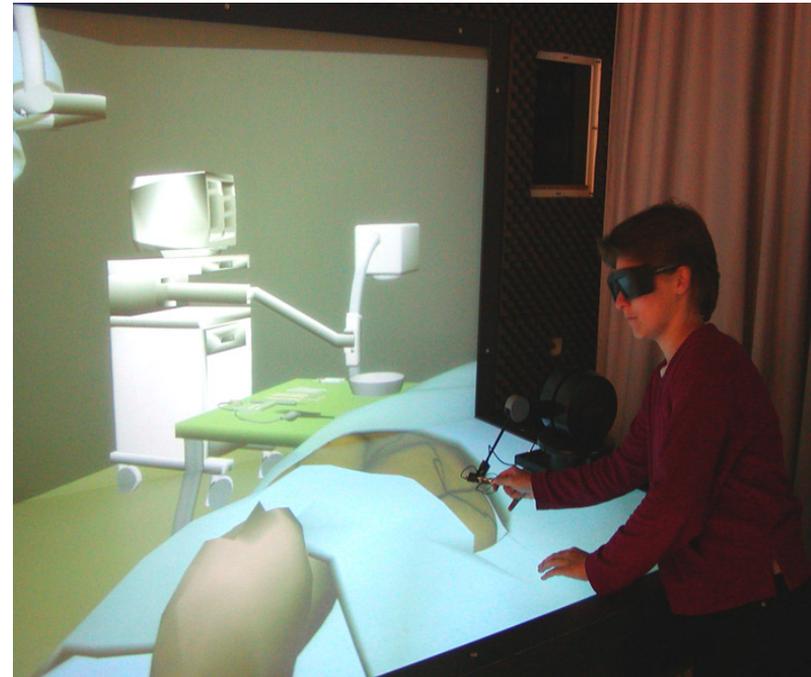
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[TVCG 14(6), 2008]

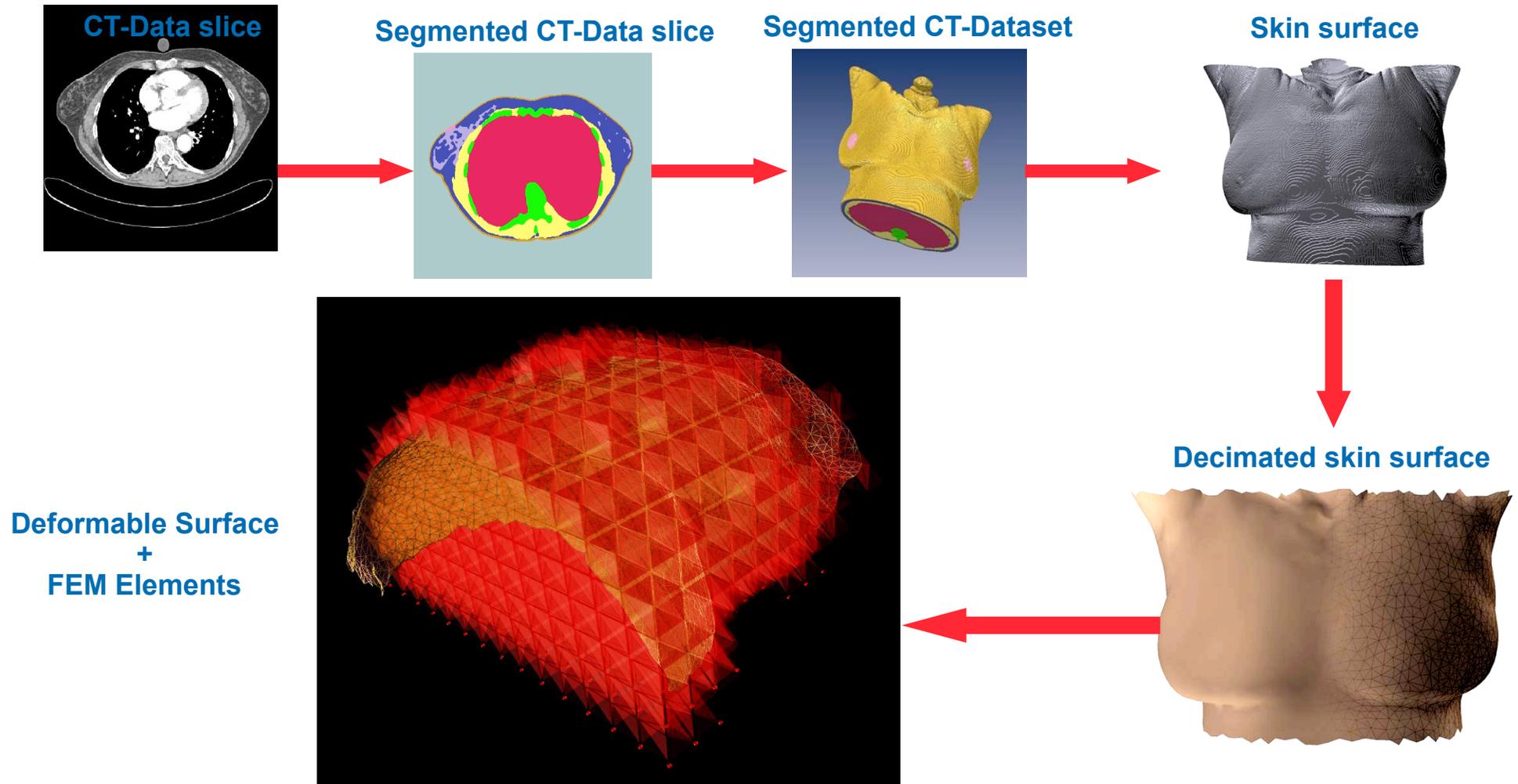
# Virtual Surgery: Cutting Deformable Objects

Lenka Jerabkova et al.



[MMVR 2005, BVM 2007, MMVR 2007, CG&A 29(2)]

# Virtual Surgery: Dataset creation



# Virtual Surgery: Cutting Deformable Objects

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## Stable Interactive Cutting of Deformable Objects

Example: Virtual Surgery

**RWTH**AACHEN  
UNIVERSITY

virtual  
reality  
group **VR**

[MMVR 2005, BVM 2007, MMVR 2007, CG&A 29(2)]

# RASim: Regional Anaesthesia Simulator

Sebastian Ullrich et al.

- Partners:
  - Dept of Anaesthesiology, Univ. Hospital Aachen (R. Rossaint)
  - Medical Informatics, RWTH (T. Deserno)
  - VR Group, RWTH (T. Kuhlen)
- Goal of Regional Anaesthesia (RA):
  - suppress function of specific nerves (block)
- Procedure:
  - identify insertion site by palpation
  - locate nerve with specialized cannula
    - emit electric impulses, cause motoric feedback
    - iterate to minimize distance to nerve
  - apply anaesthetics
  - verify nerve block



[[www.nerveblocks.de](http://www.nerveblocks.de)]

# RASim: Motivation

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## Problem:

- RA procedures complex and error-prone
- 40 – 70 nerve blocks needed to gain proficiency and safety
- Few training opportunities
  - Only infrequent training on patients
  - Cadavers (no motor response, changing material properties)

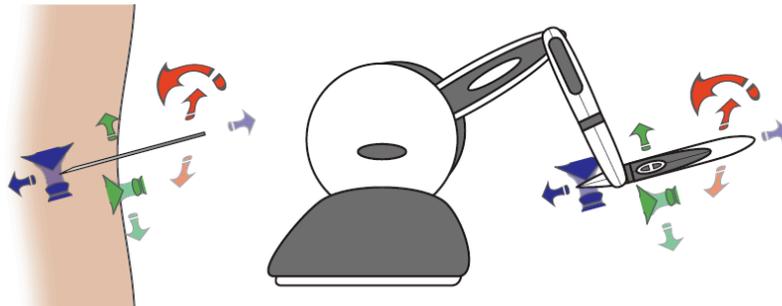
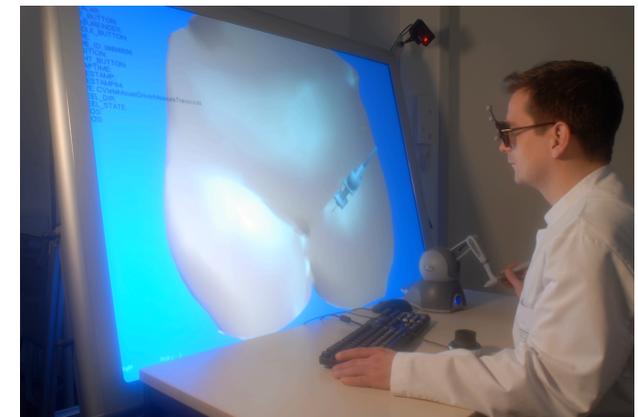
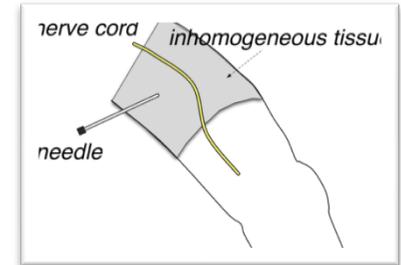
## Solution:

- Provide VR-based training opportunity
  - Convey experience for routine procedures
  - Also train complex scenarios/rare complications
  - Train variations in anatomy

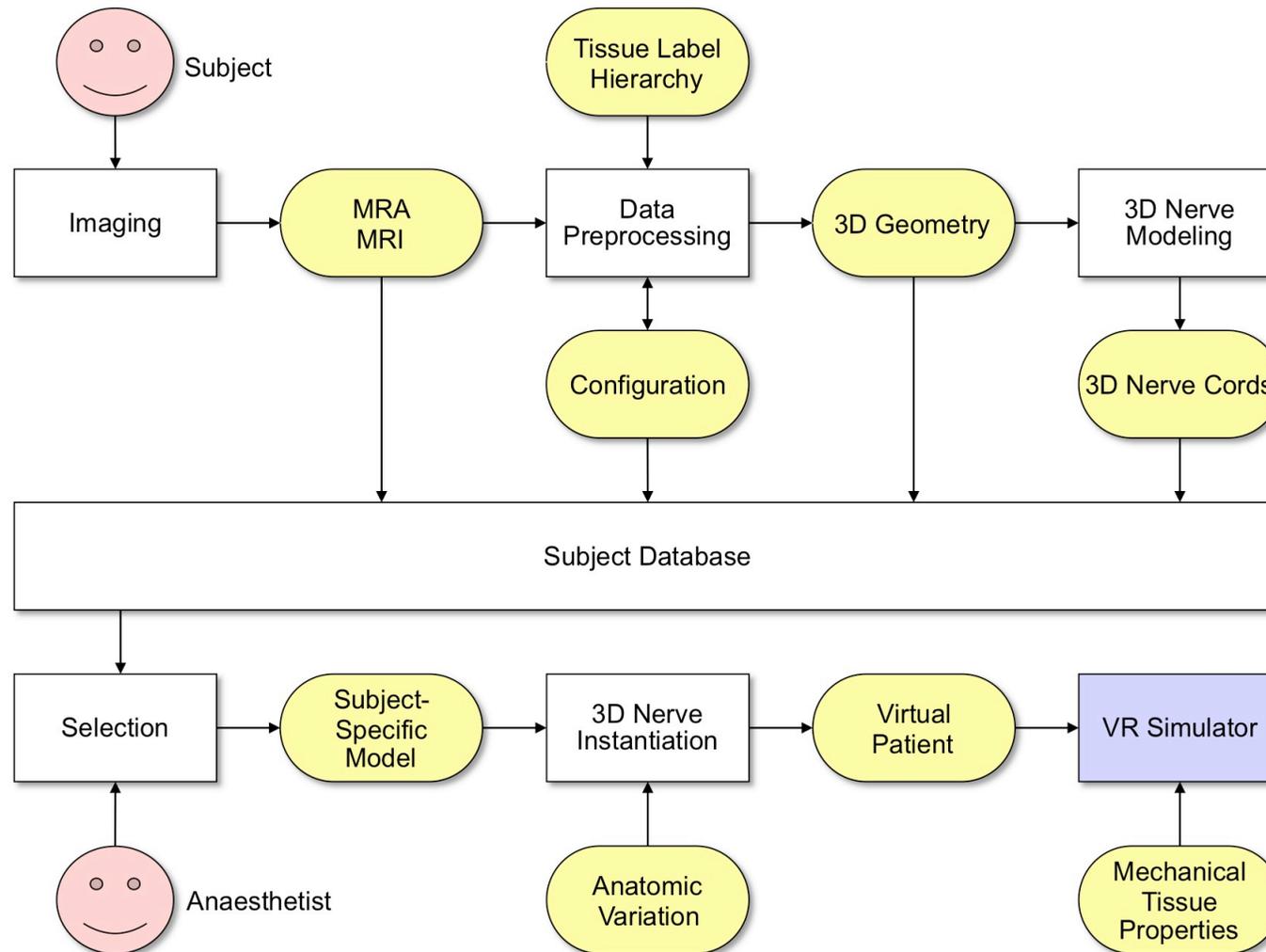
# RASim: Research Aspects

- Medical Datasets: Innovative segmentation methods
- 6 DOF editor for geometric modeling of peripheral nerves
- Simulator: High-performance, parallel architecture
- Electric impulse transmission: “Electrical distance “
  - Based on electrical resistance combined with pathfinding instead of simple geometric distance
- Nerve stimulation and muscle activation
- First user study showed promising results
- Current Work: Haptic Feedback!

[BVM 2007/2008, SPIE MI 2008, MMVR 2009,  
CARS 2009, BJA 2009, ...]

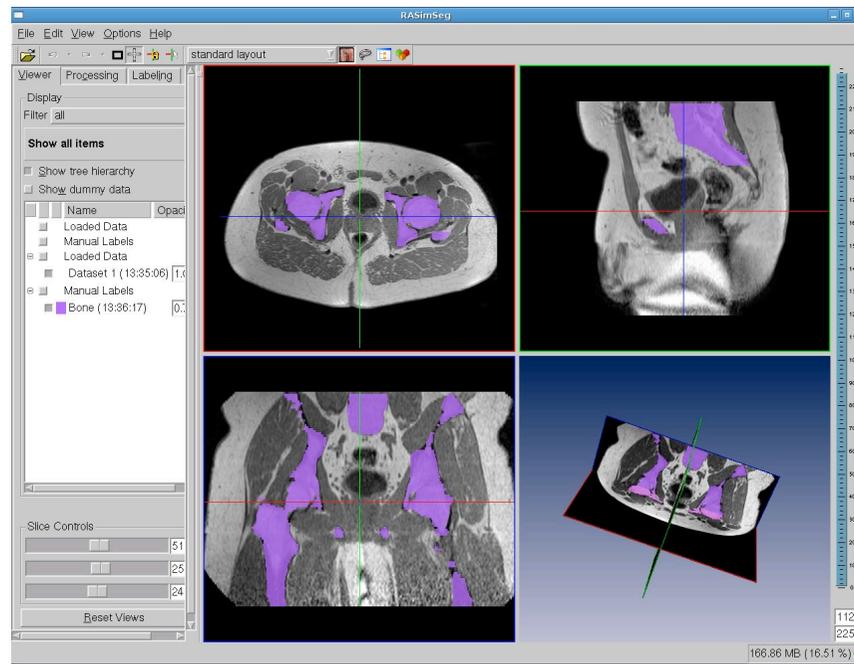


# RASim: Content Creation Pipeline



# RASim: Segmentation

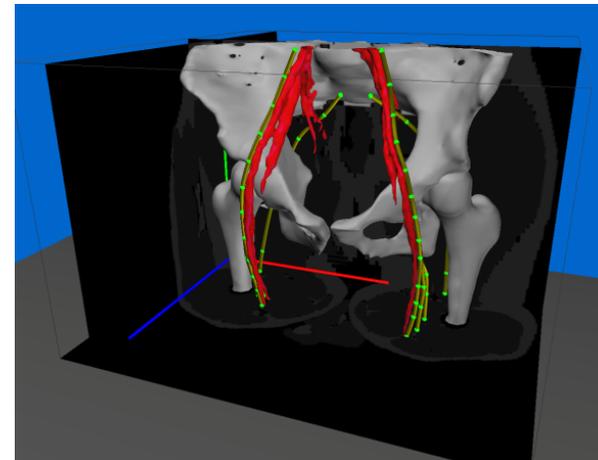
- Manual segmented reference data sets
- Semi-automatic segmentation
  - Application based on Medical Imaging Toolkit (MITK)
  - Specific segmentation algorithm for each tissue type



# RASim: 3D Nerve Modeling

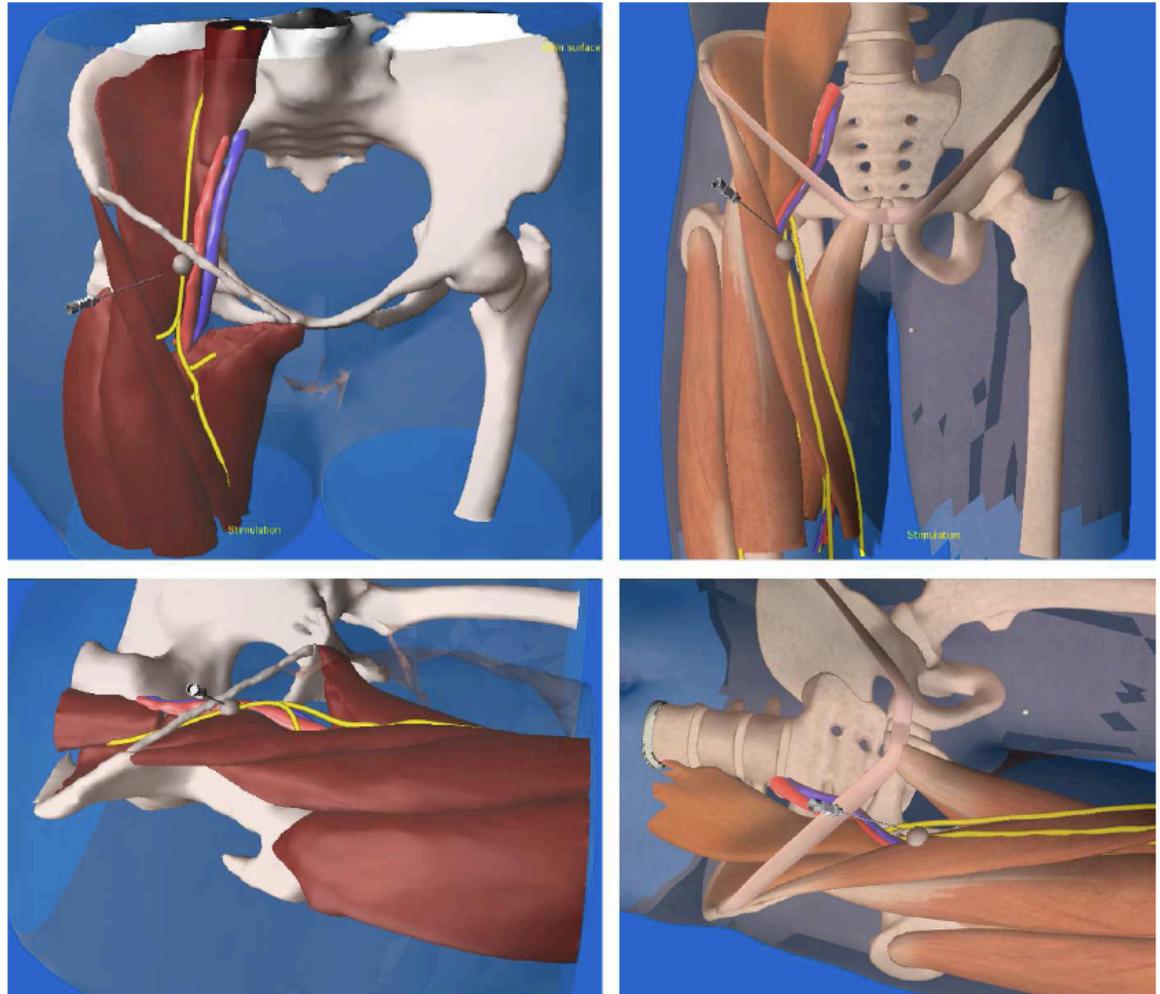
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- Problem:
  - Nerve cords cannot be seen/extracted from medical images
- Solution:
  - VR-based modeling software to model peripheral nerves
  - Use additional anatomical structures/scans as reference

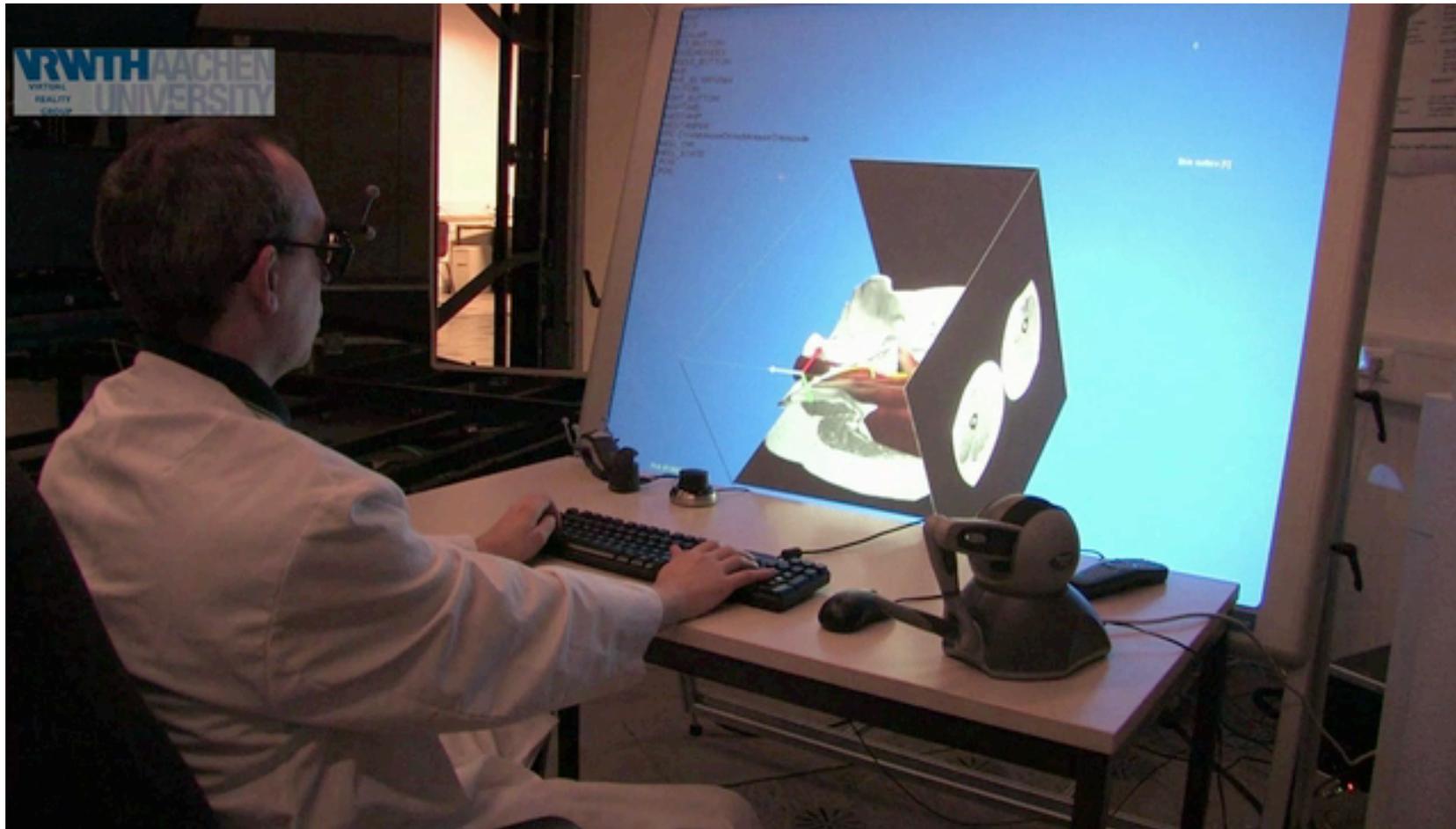


# RASim: Resulting Datasets

- Focus on inguinal region
- Manual reference (left)
  - Segmented from MRI and MRA scans
- Commercial model (right)
  - Created by Zygote
  - Full body



# RASim: Demo video



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# Thank You!

[www.vr.rwth-aachen.de](http://www.vr.rwth-aachen.de)

[www.rasim.info](http://www.rasim.info)