# Cognition-guided heart surgery II
The role of computer science

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Cognition-Guided
Surgery

dkfz.
GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION

50 Years – Research for
A Life Without Cancer
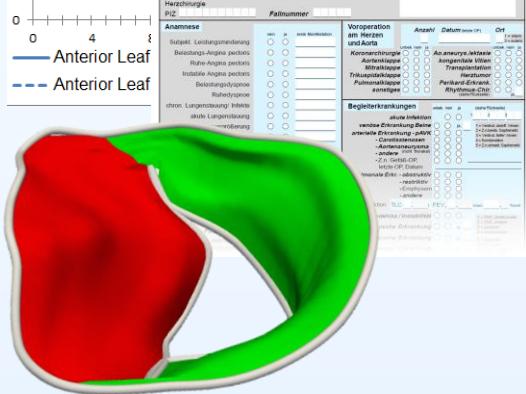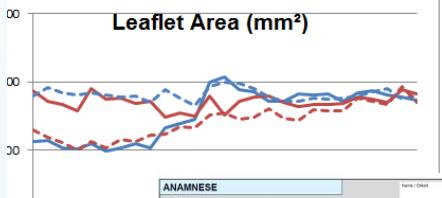
Cognition-guided heart surgery

Knowledge base

Ontology
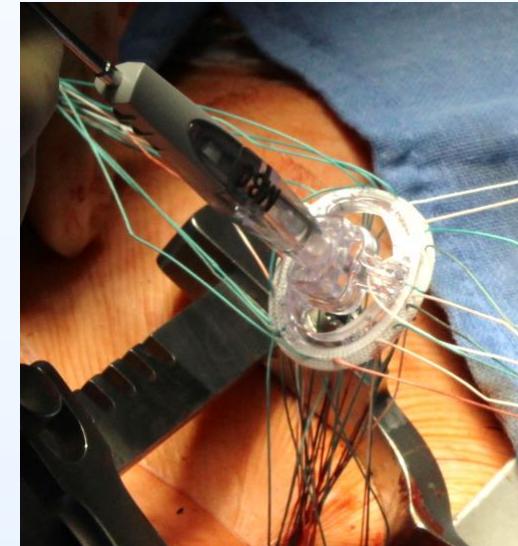
Perception

data acquisition
before, during and after surgery

Interpretation

Ring „Edwards Physio II", Size 32

Action

Annuloplasty ring selection

Preoperative Diagnosis

dkfz.

50 Years – Research for
A Life Without Cancer

*Two-Dimensional Echocardiography*
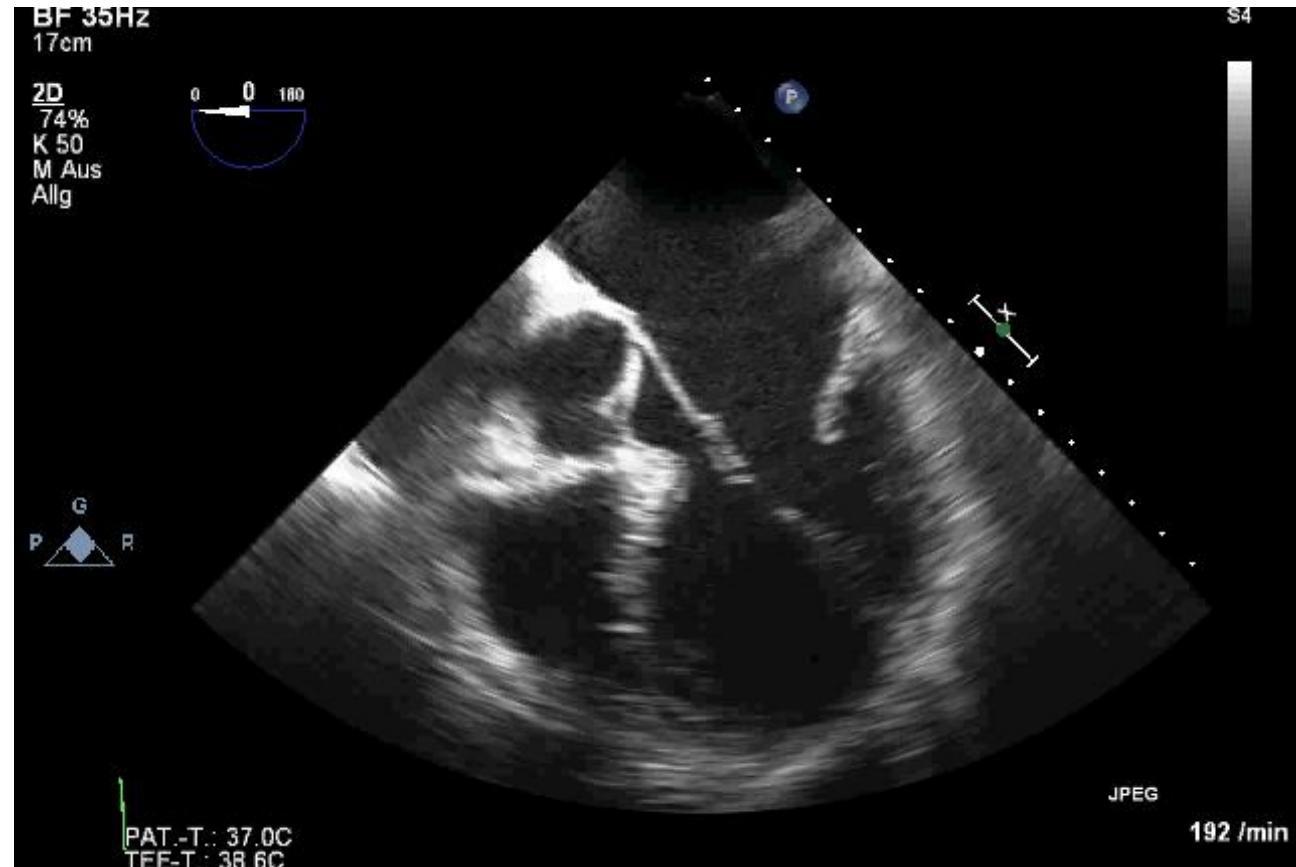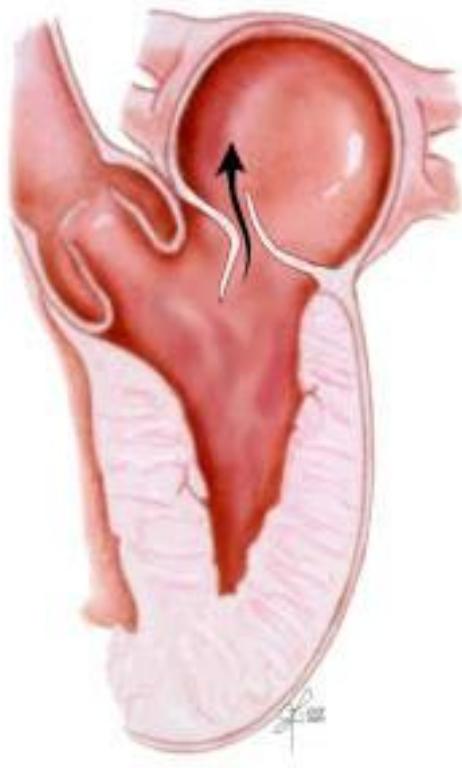
☺ high temporal resolution, cheap, widely used

3D-TEE *en face* View = Surgical View

Three-Dimensional Echocardiography

Mitral Annulus Modelling
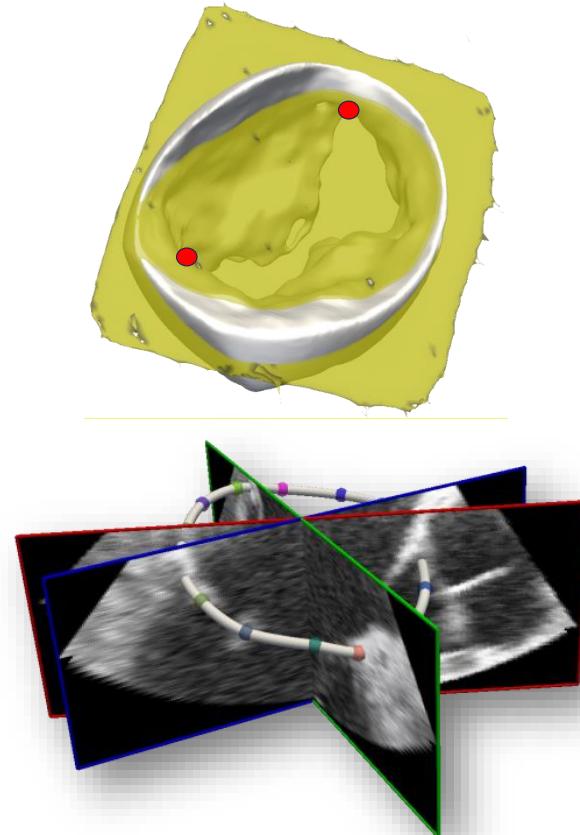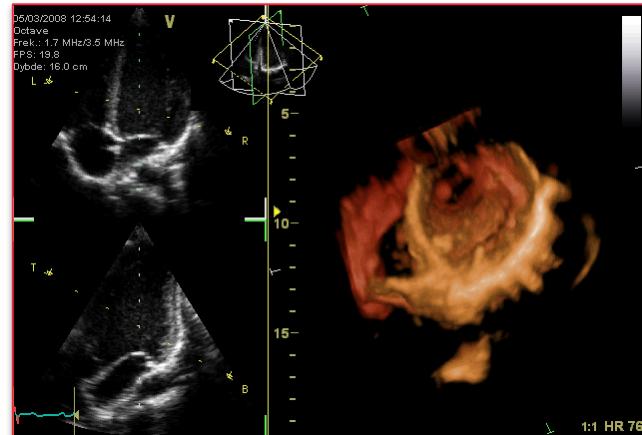
3D+t Echo-
cardiography

Interactive Setting of Annulus Plane
and Commissural Points;
Placing of an Empirical Standard Model

3D+t Mitral
Annulus Model

[1] **Graser B. et al., International Journal of CARS 2013** - Using a Shape Prior for Robust Modeling of the Mitral Annulus on 4D Ultrasound Data.

Mitral Annulus Modelling
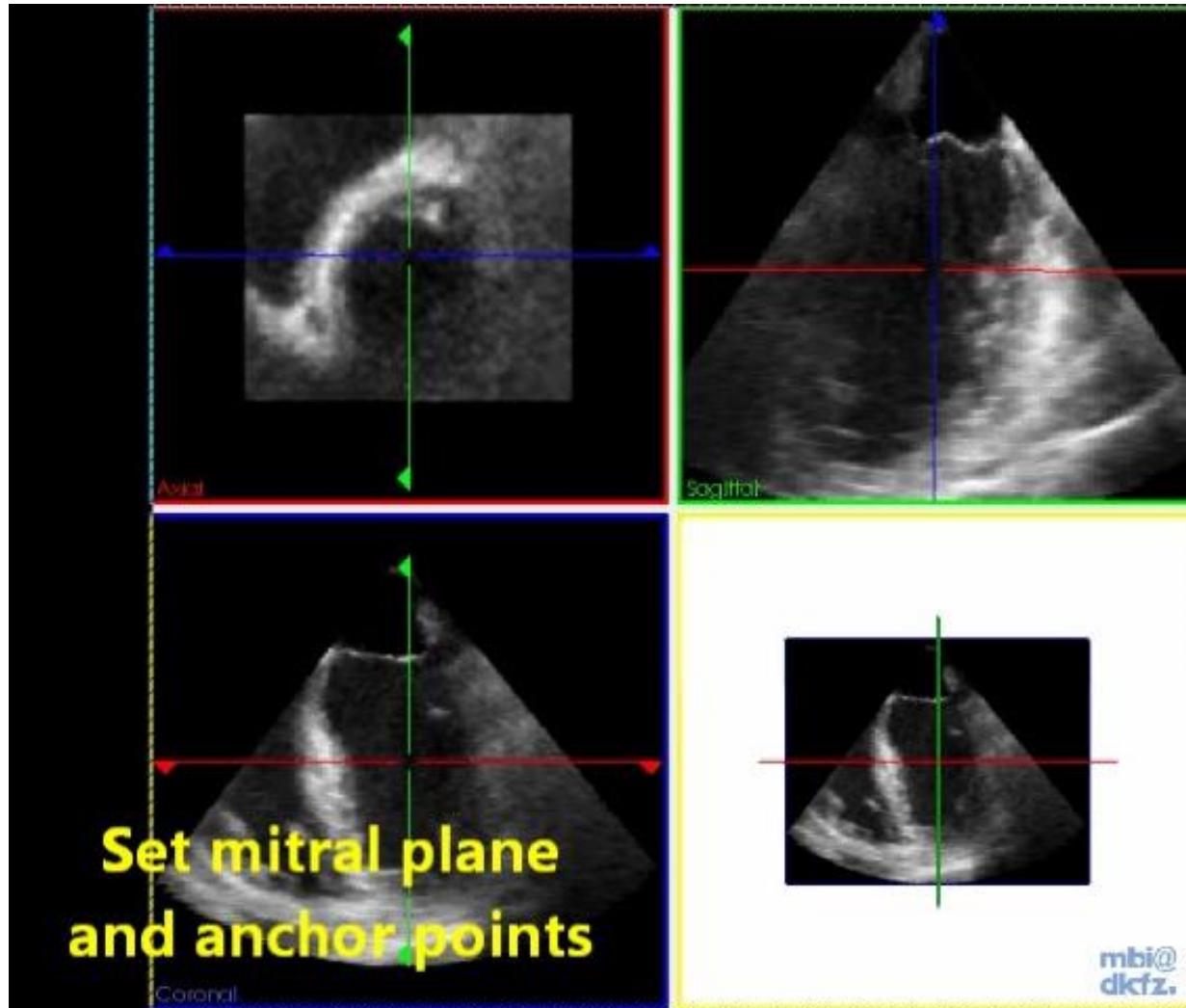
Enhanced Disease Characterization

## Time-based Quantifications [1]

AL-PM Diameter 3D

A-P Diameter 3D

[1] **Graser B. et al., International Journal of CARS 2013** - Using a Shape Prior for Robust Modeling of the Mitral Annulus on 4D Ultrasound Data.

7

Mitral Leaflets Modelling
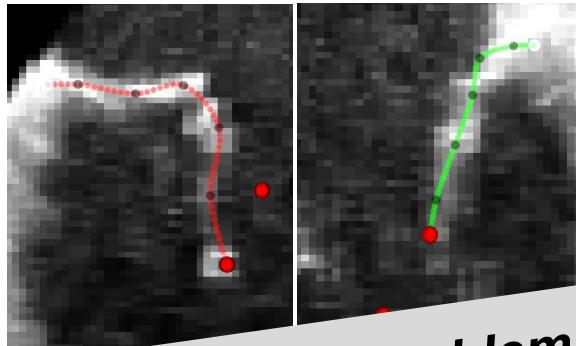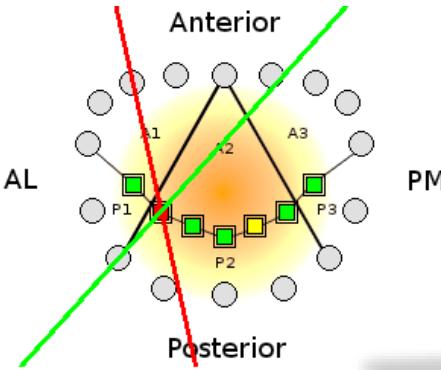
Problem:
*Interactive Segmentations
are labor-intensive*
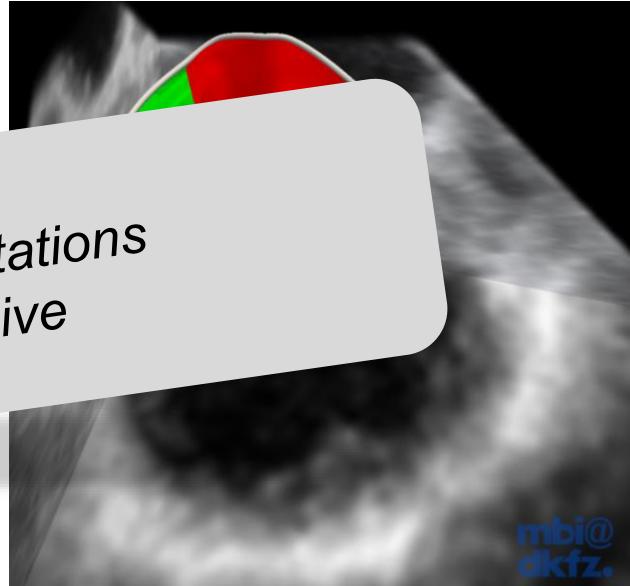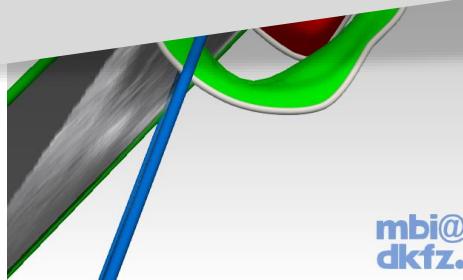
Intuitive
slicing concept

Interactive Setting of
Leaflet Tips and Body Points

3D+t Mitral
Valve Modell

Valve Segmentation

Automatic Modelling
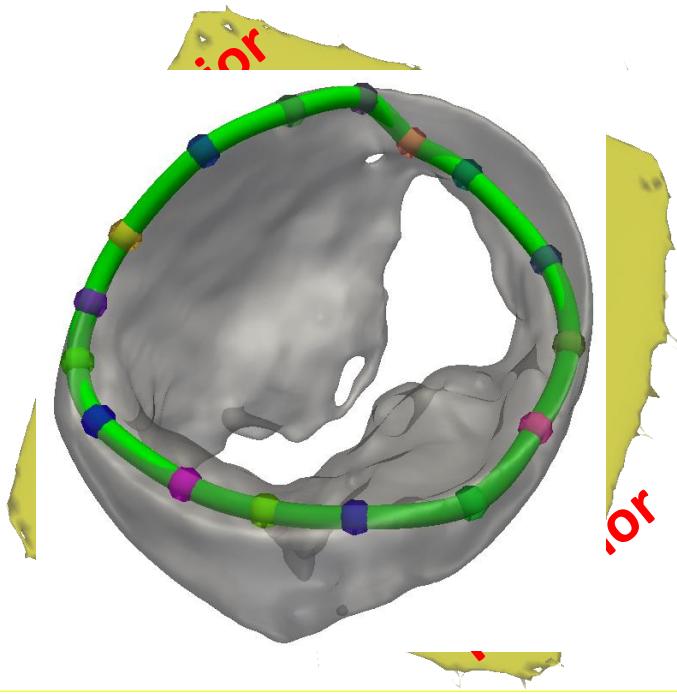
- External Force $\vec{F}_E$

- Internal Force $\vec{F}_I$

- Temporal Force $\vec{F}_T$

$$\vec{F} = w_E \cdot \vec{F}_E + \vec{F}_I + w_T \cdot \vec{F}_T$$

Valve Segmentation

Internal Force

- Adjustments to anatomically plausible angles and point-distances
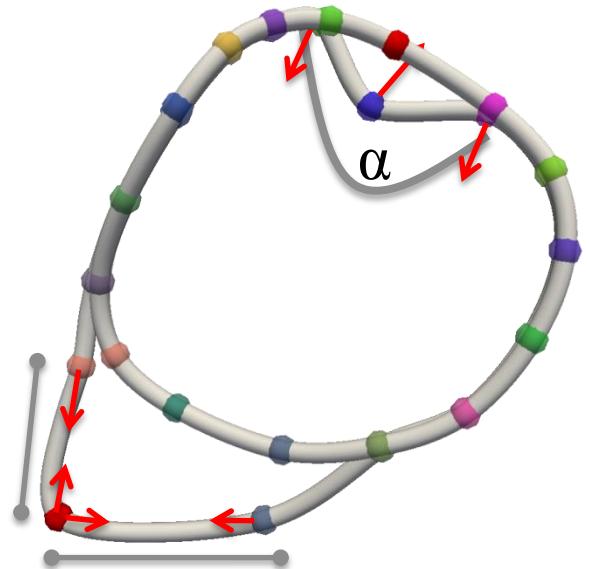
External Force

- Adjustment to image information

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[1] **Graser B. et al., International Journal of CARS 2013** - Using a Shape Prior for Robust Modeling of the Mitral Annulus on 4D Ultrasound Data.
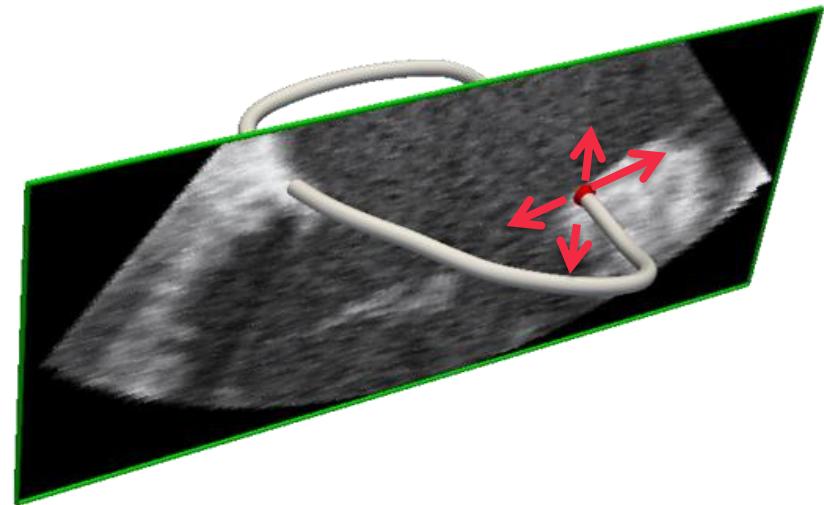
Valve Segmentation

Temporal Force

- Adjustments to a sinusoidal movement
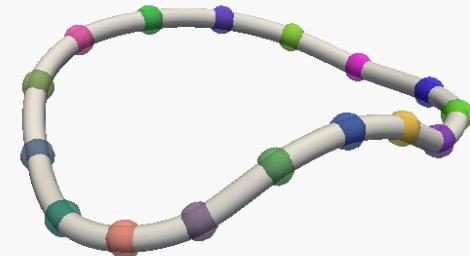
- robust to low image quality and severe pathologies
- 2.25 mm average error
- results are on the scale of experts' models

Current Model

[1] **Graser B. et al., International Journal of CARS 2013** - Using a Shape Prior for Robust Modeling of the Mitral Annulus on 4D Ultrasound Data.
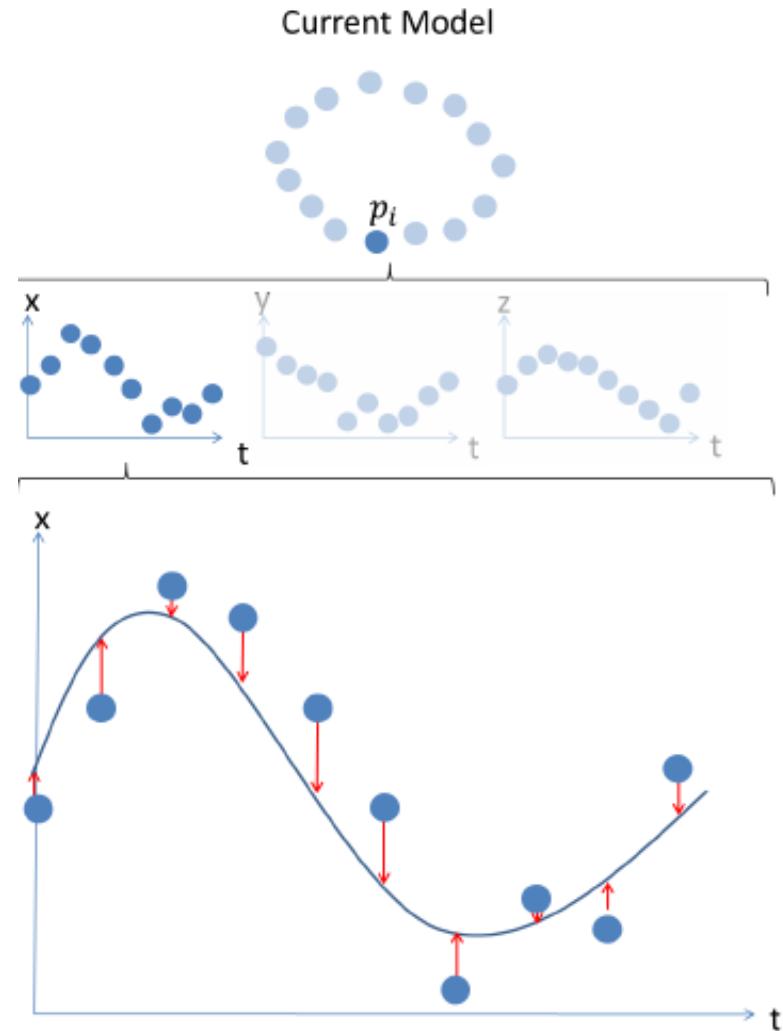
Valve Segmentation

Spatio-temporal mitral leaflets modelling
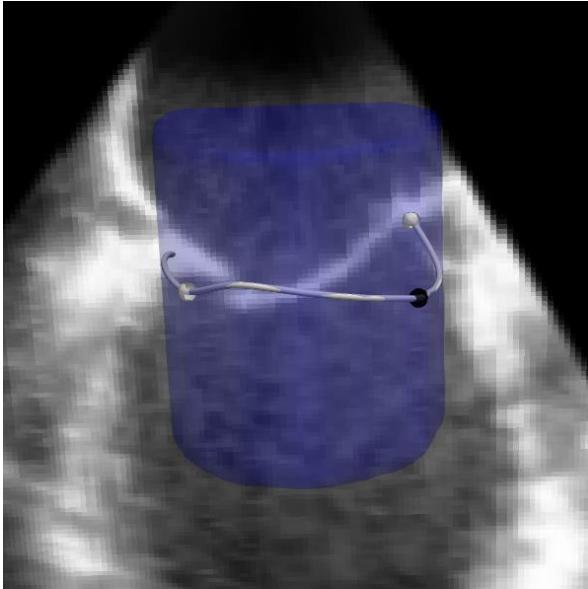


Region of Interest
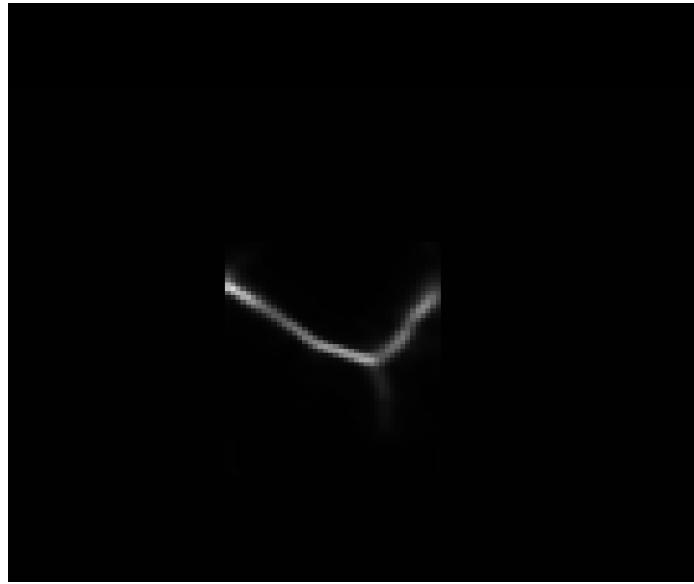
Thin Tissue Detector
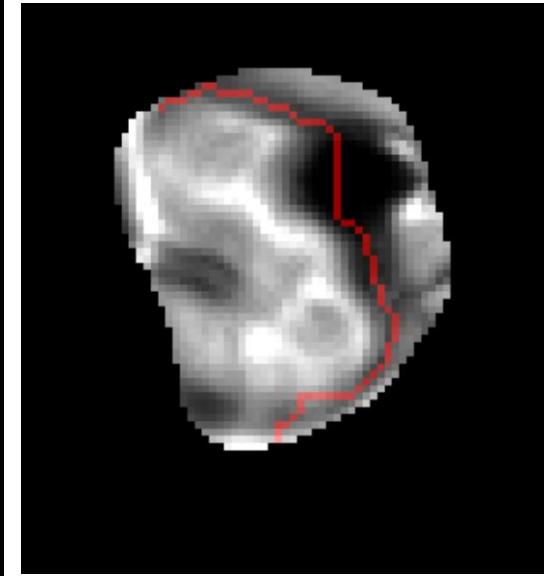
Leaflet Separation Using Graph Cuts

[1] **Engelhardt, S. et al., Functional Imaging and Modelling of the Heart 2015** - Towards Automatic Assessment of the Mitral Valve Coaptation Zone from 4D Ultrasound.

Valve Segmentation
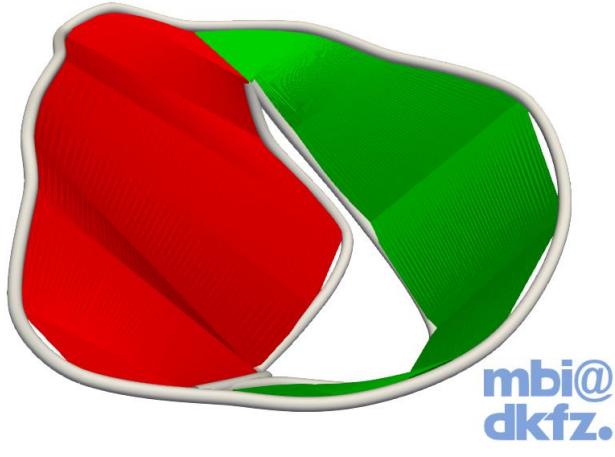
Model Initialization
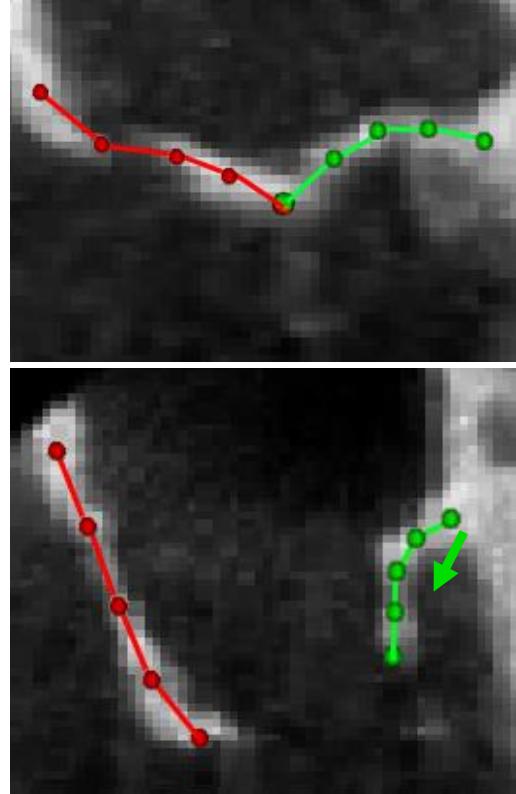
Model Optimization
Over the Whole Cycle

3D+t Mital Valve
Model

[1] **Engelhardt, S. et al., Functional Imaging and Modelling of the Heart 2015** - Towards Automatic Assessment of the Mitral Valve Coaptation Zone from 4D Ultrasound.

Valve Segmentation

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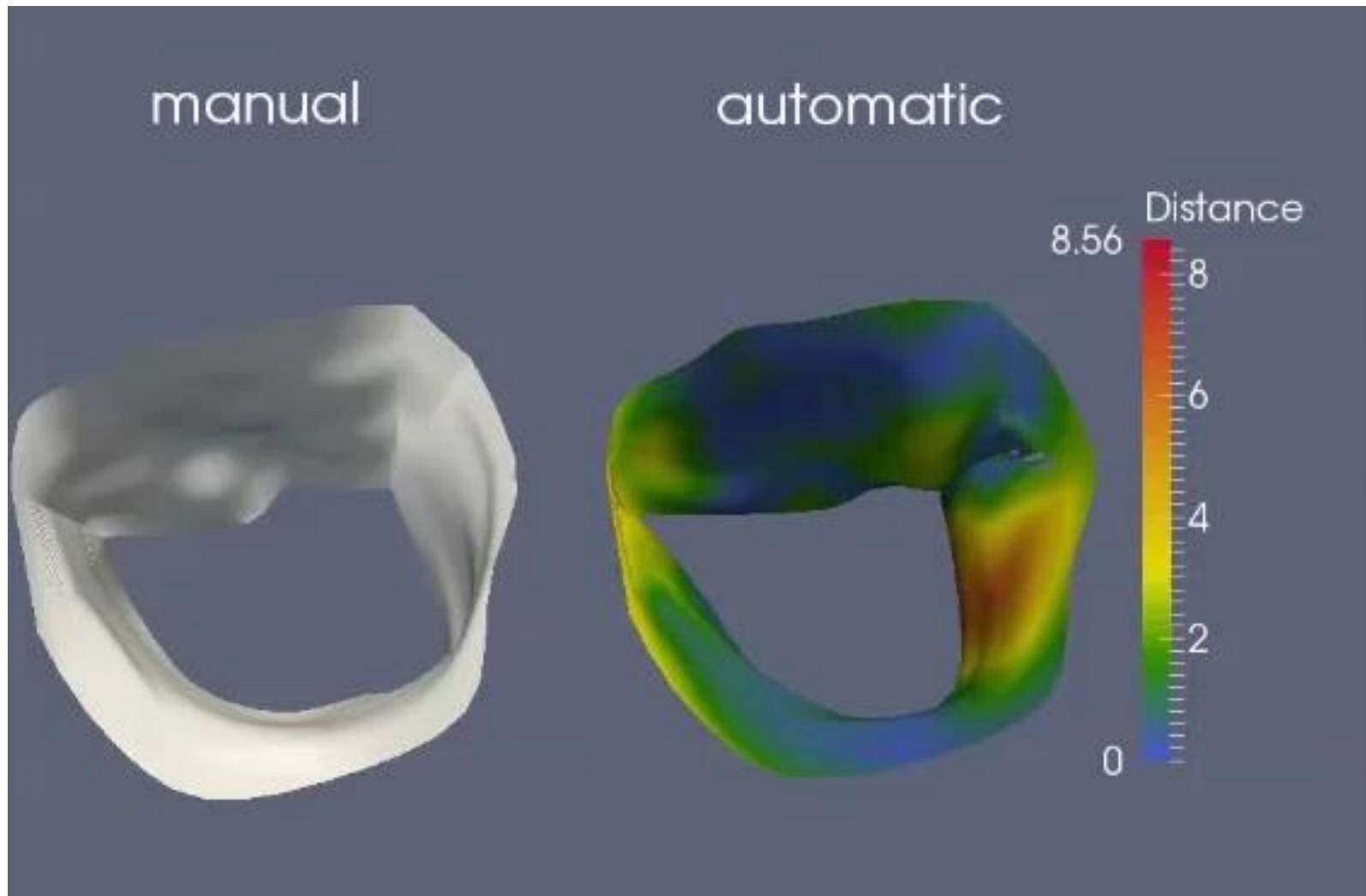
Automatic Coaptation Zone Assessment
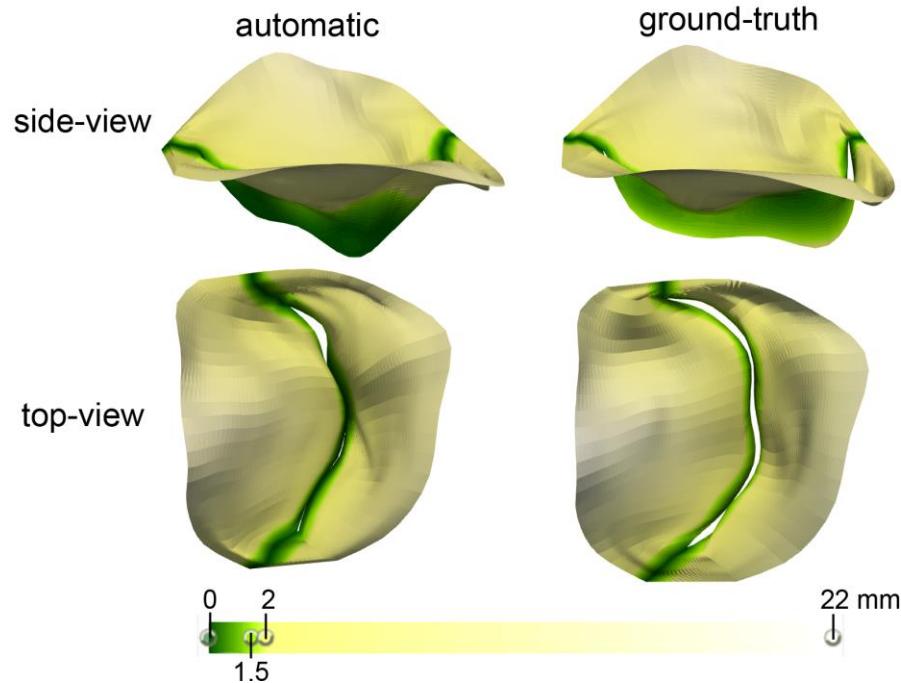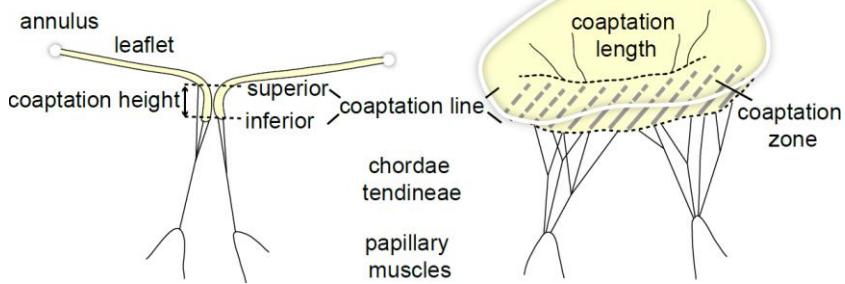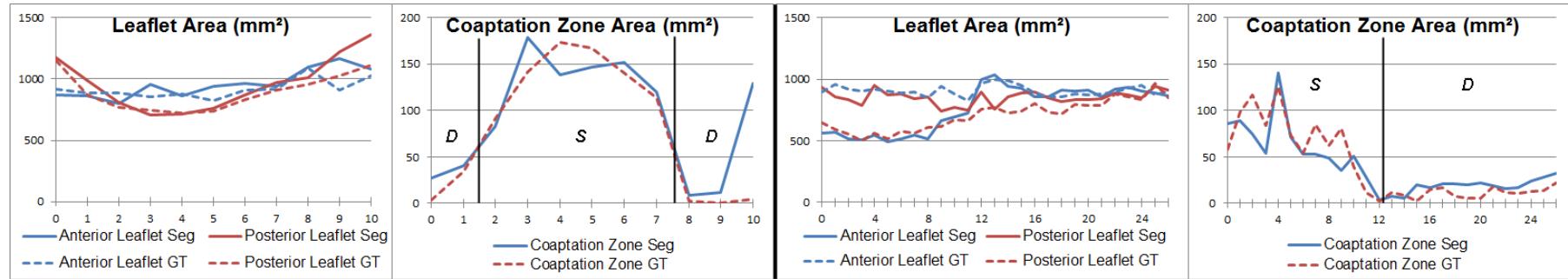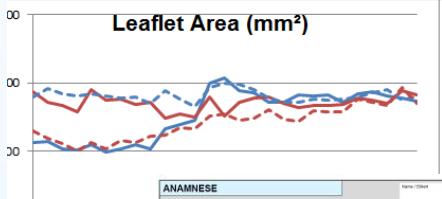
[1] **Engelhardt, S. et al., Functional Imaging and Modelling of the Heart 2015** - Towards Automatic Assessment of the Mitral Valve Coaptation Zone from 4D Ultrasound.

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Perception

data acquisition
before, during and after surgery

Interpretation

Ring „Edwards Physio II", Size 32

Action

Annuloplasty ring selection

16
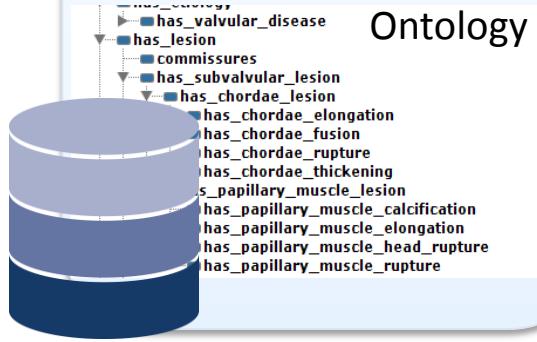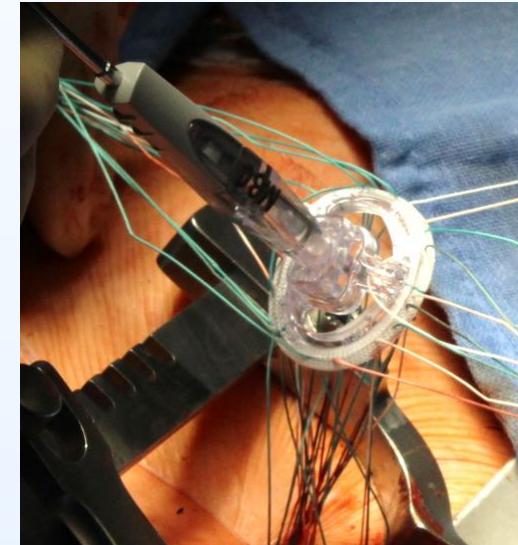
XNAT data management

- Open source imaging informatics platform, developed by the Neuroinformatics Research Group at Washington University St. Louis
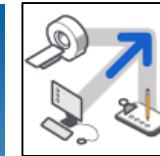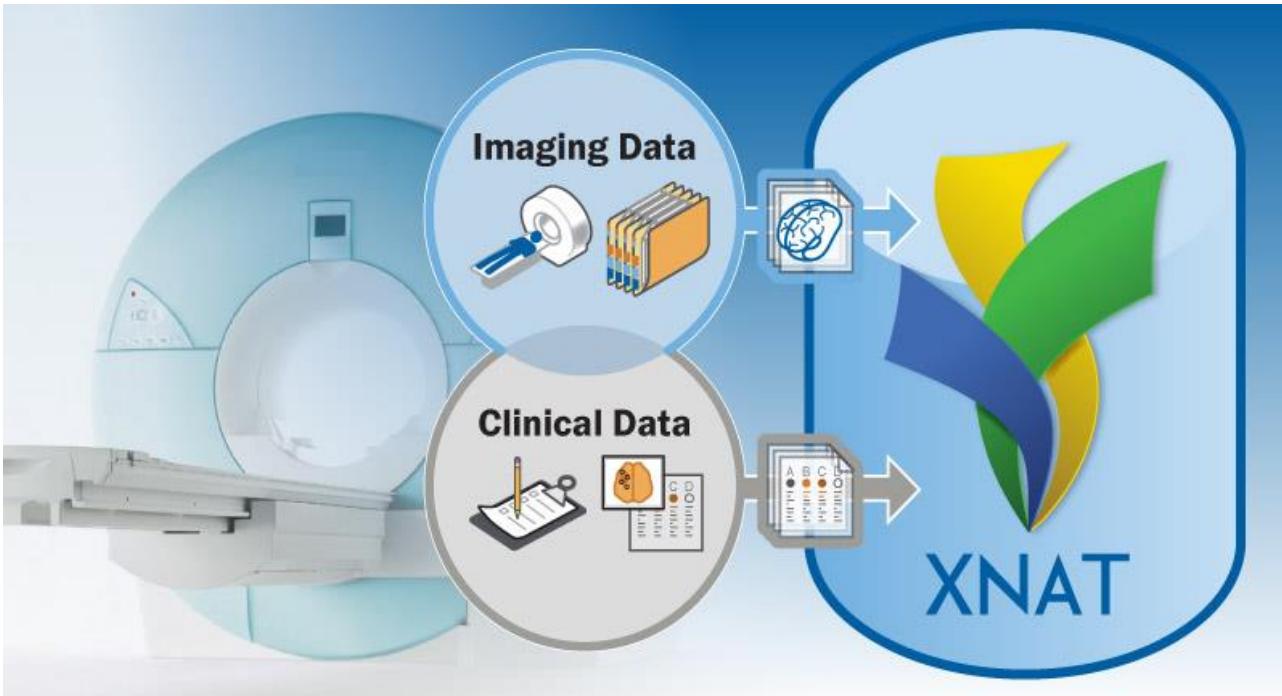
Upload any kind of data
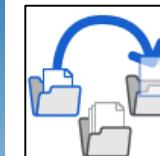
Organize and share data
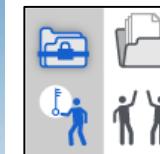
Role permission system

View and Download data

www.xnat.org

17

XNAT integration

50 Years – Research for A Life Without Cancer

Data Processing & Development in open–source MITK
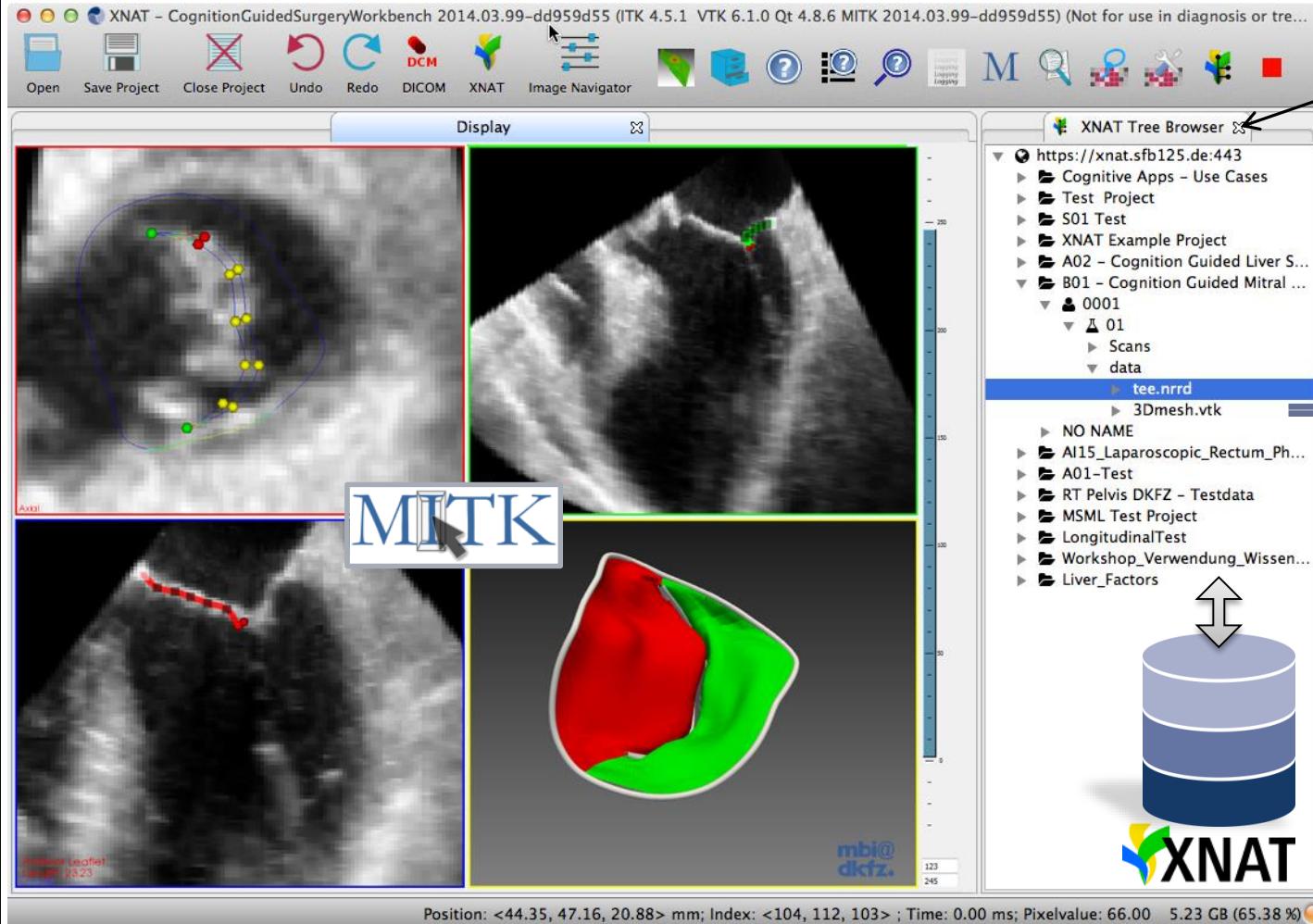
XNAT Tree Browser Plugin

<is derived from>

<type description>

Semantic Representation

Intraoperative Valve Analysis

Sizing for Mitral Annuloplasty: Where Does Science Stop and Voodoo Begin?

Wolfgang Bothe, MD, D. Craig Miller, MD, and Torsten Doenst, MD

▸ **Problem: no standardized approach!**
   ⇨ **variability of methods & results**

distance trigone

size anterior leaflet

height anterior leaflet

Bothe, W., Miller, D.C., Doenst, T., 2013. Sizing for Mitral Annuloplasty: Where Does Science Stop and Voodoo Begin? The Annals of Thoracic Surgery 95, 1475–1483.

Sandy Engelhardt

MBI

5/27/2015 | Page21
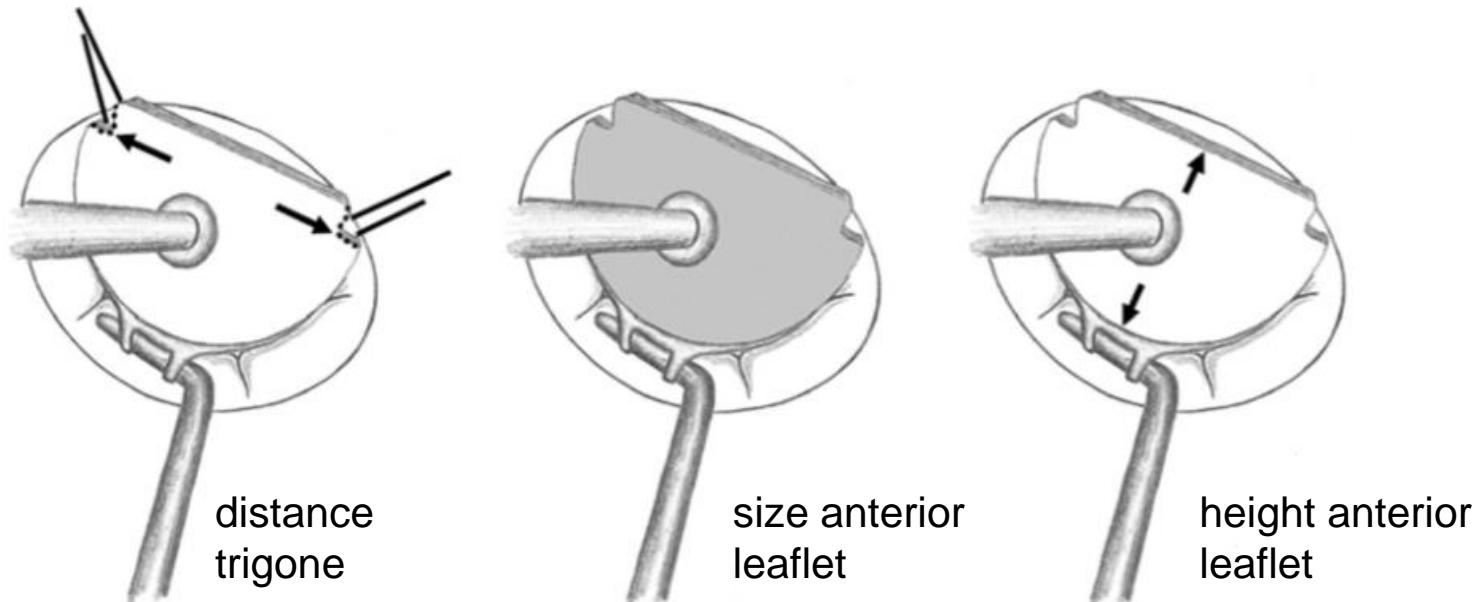
Intraoperative Valve Analysis

Visual assessment performed by the surgeon:
annuloplasty ring sizing with "sizer"
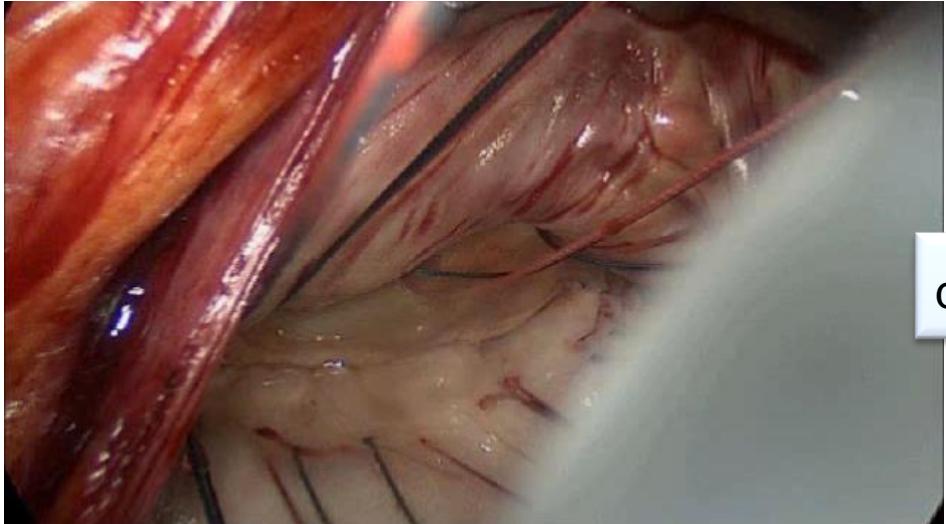
decision

# Intraoperative Decision Support

spatial measurements

*visual guidance
& cognition-guided
decision support*
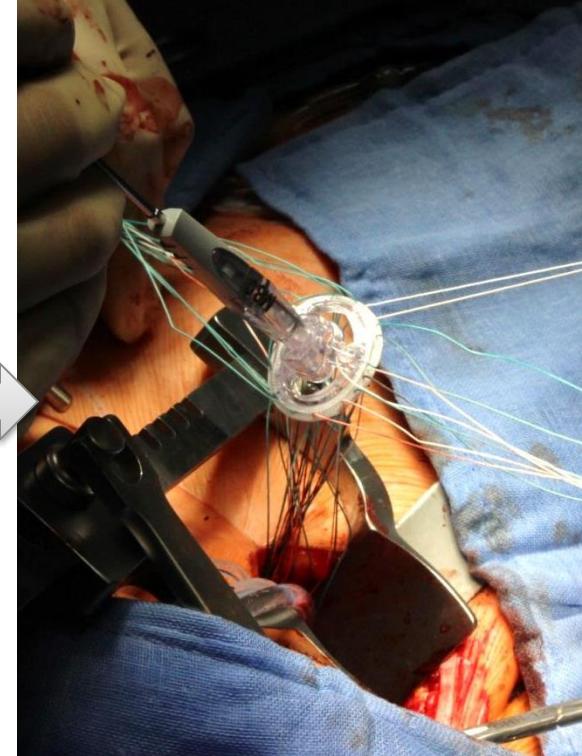
ring implantation

Intraoperative Decision Support

Application of the intraoperative assistance system (4 x) :
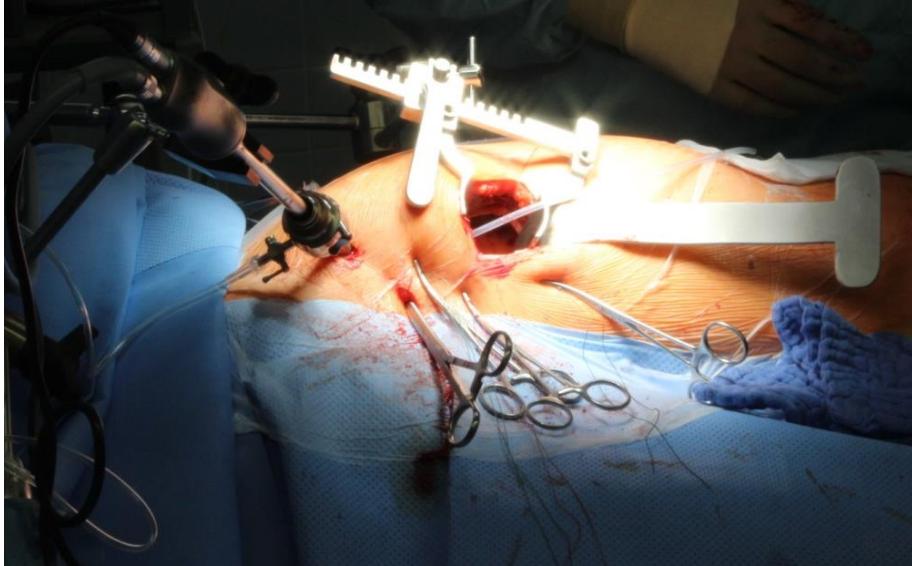
1x minimal invasive mitral valve reconstruction

2x open mitral valve replacement
1x open mitral valve reconstruction
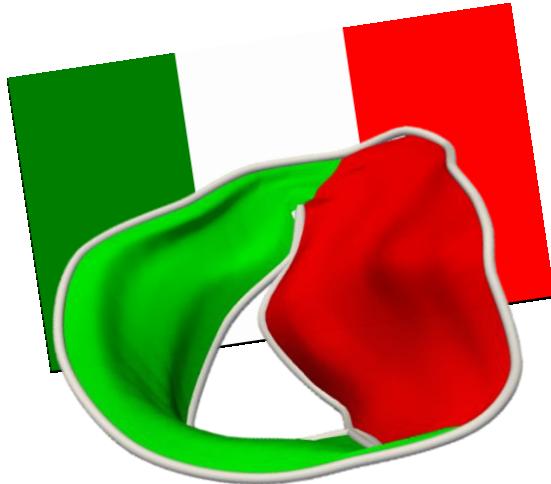
Mille grazie!

Raffaele De Simone   Sandy Engelhardt