

5/27/2015

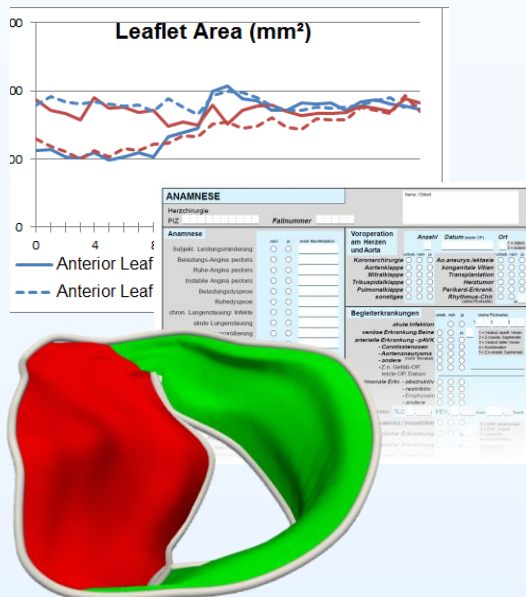
Cognition-guided heart surgery II

The role of computer science

Sandy Engelhardt

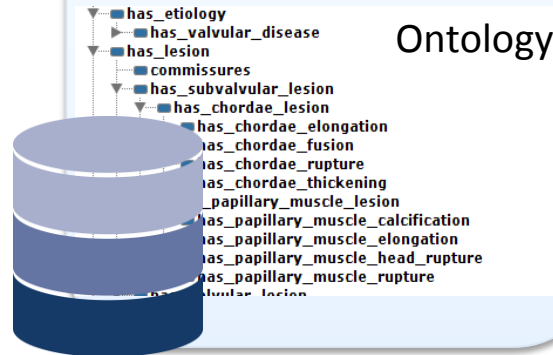
Medical and Biological Informatics, DKFZ Heidelberg, Germany

Perception



data acquisition
before, during and after surgery

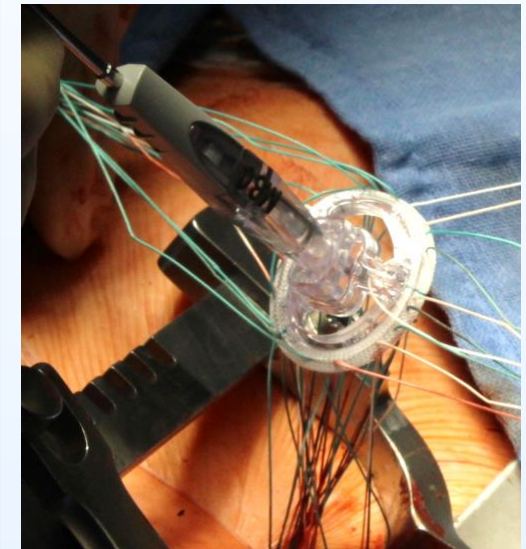
Knowledge base



Interpretation

Ring
„Edwards
Physio II“,
Size 32

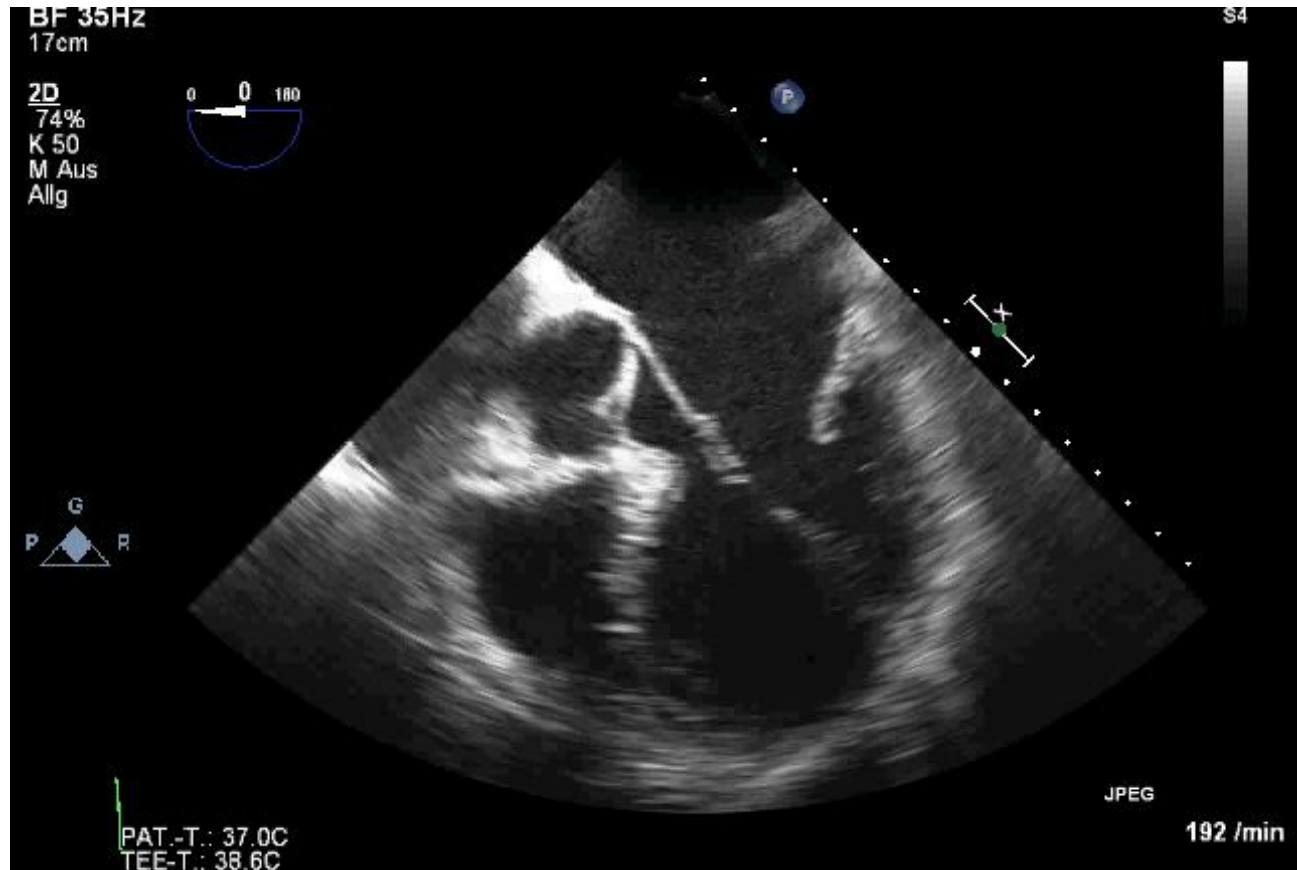
Action



Annuloplasty ring selection

Preoperative Diagnosis

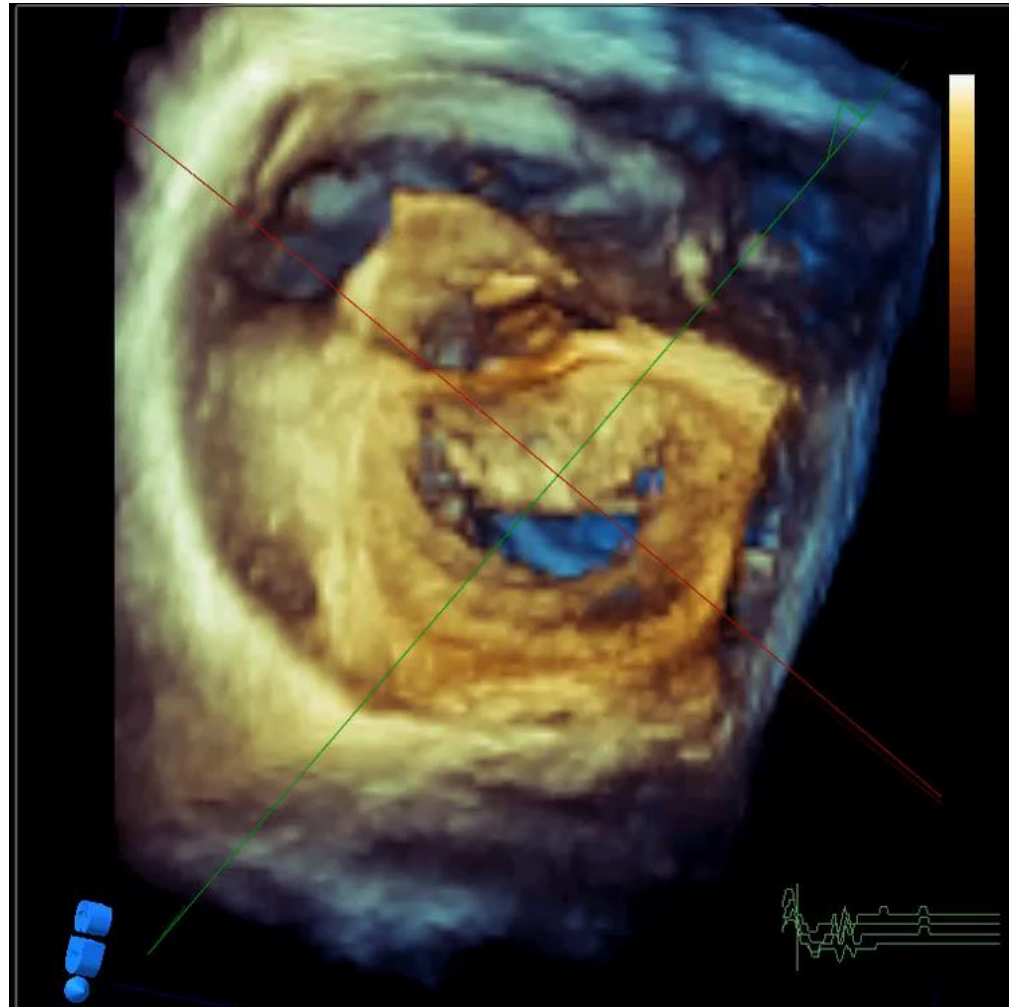
Two-Dimensional Echocardiography



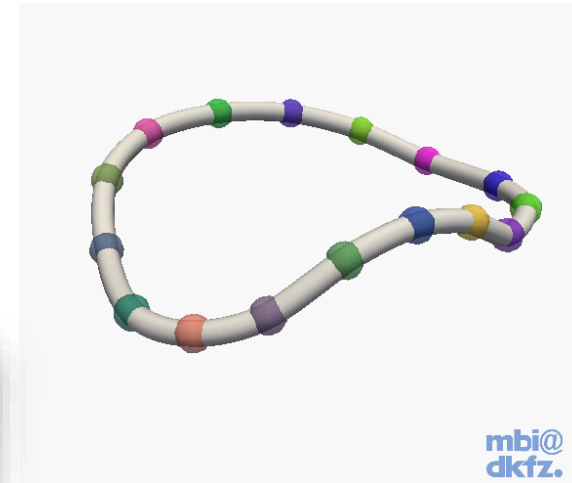
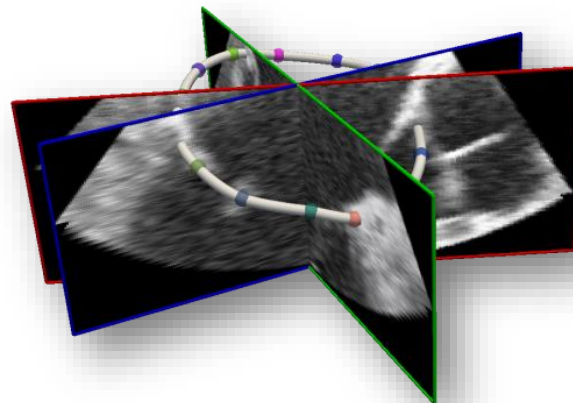
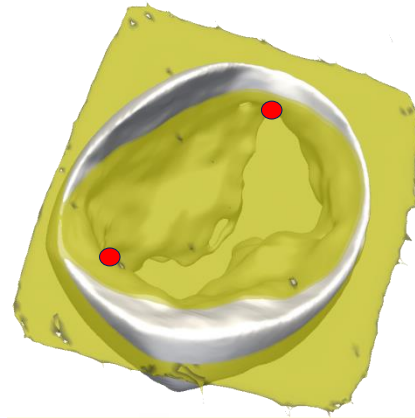
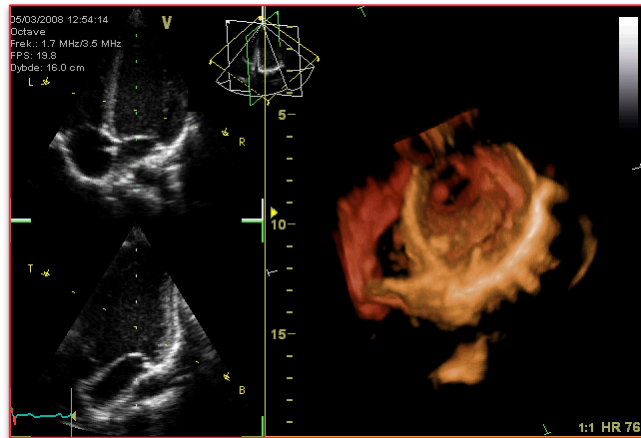
☺ high temporal resolution, cheap, widely used

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

Three-Dimensional Echocardiography



Mitral Annulus Modelling

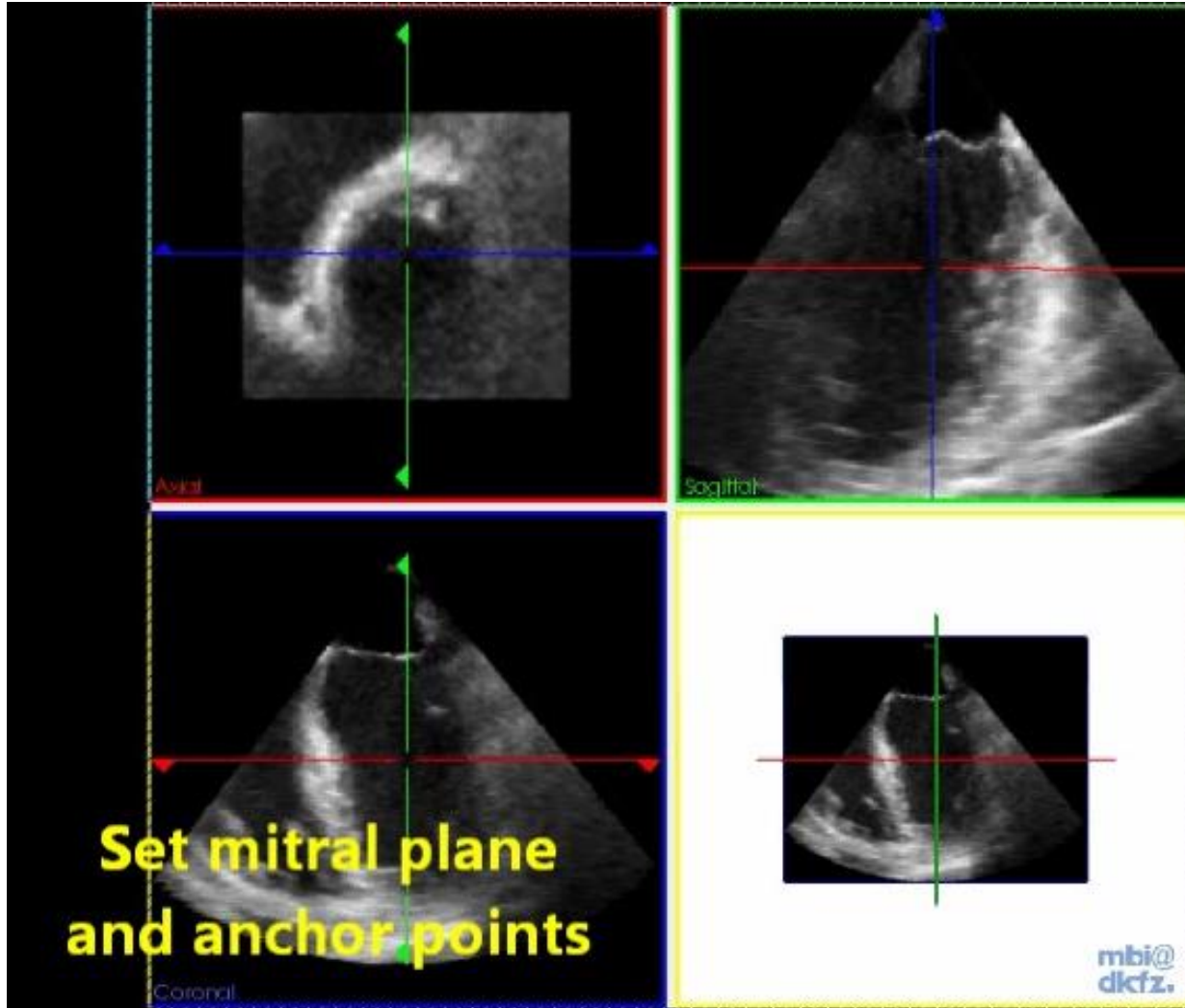


3D+t Echo-
cardiography

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

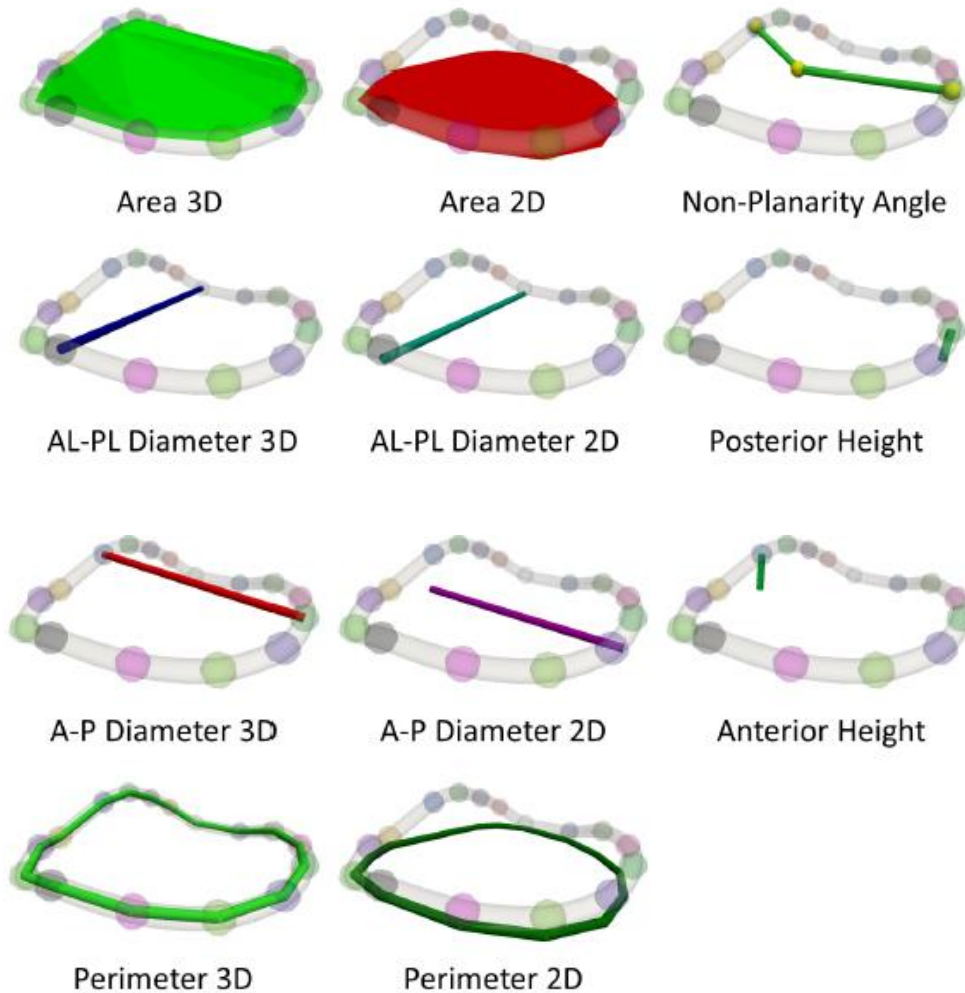
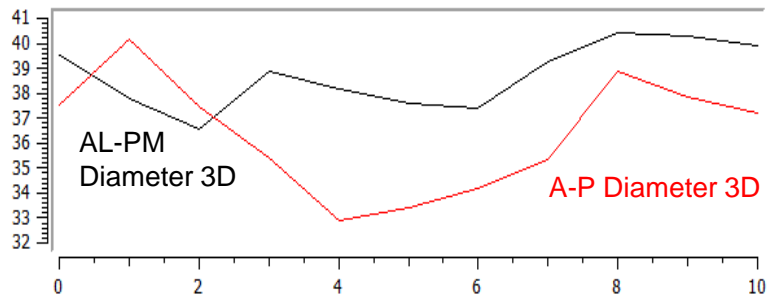
3D+t Mitral
Annulus Model

Mitral Annulus Modelling



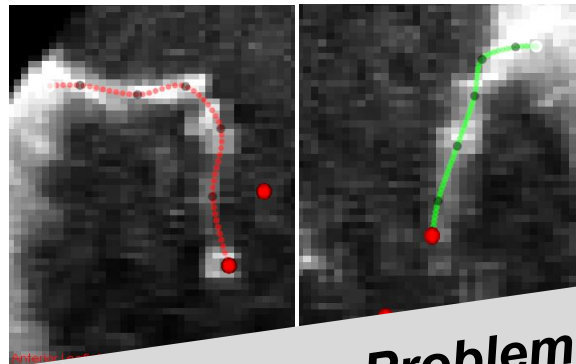
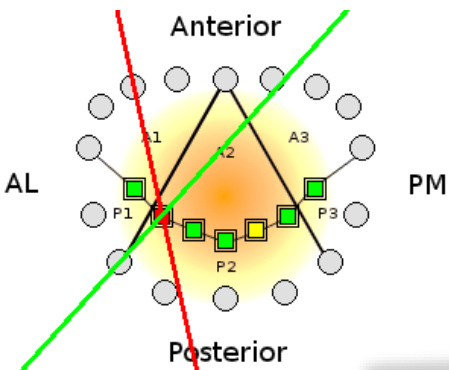
Enhanced Disease Characterization

Time-based Quantifications [1]

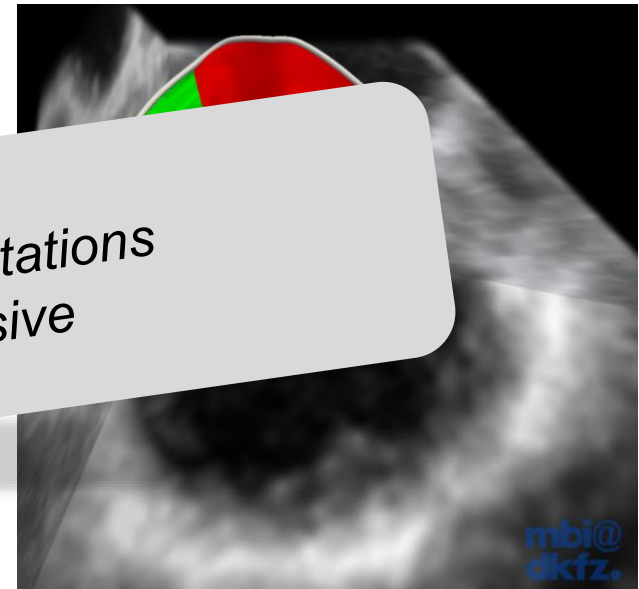


[1] Graser B. et al., International Journal of CARS 2013 - Using a Shape Prior for Robust Modeling of the Mitral Annulus on 4D Ultrasound Data.

Mitral Leaflets Modelling



Problem:
Interactive Segmentations
are labor-intensive



Intuitive
slicing concept

Interactive Setting of
Leaflet Tips and Body Points

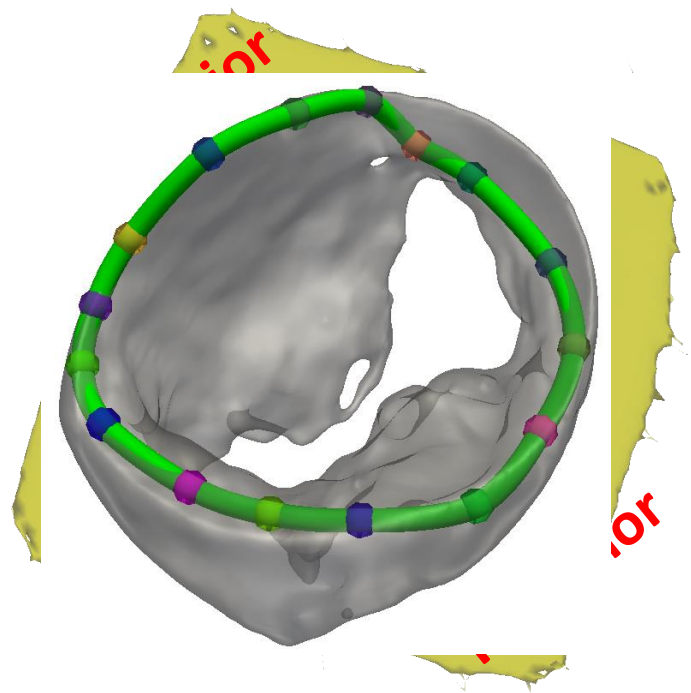
3D+t Mitral
Valve Modell

Automatic Modelling

- External Force
- Internal Force
- Temporal Force

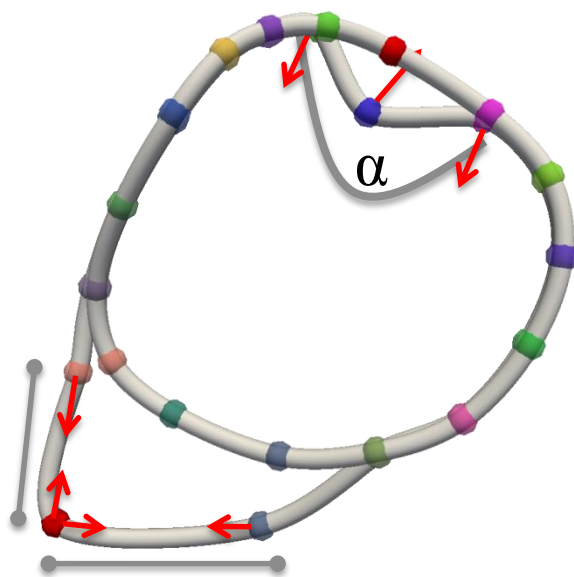
 \vec{F}_E \vec{F}_I \vec{F}_T

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



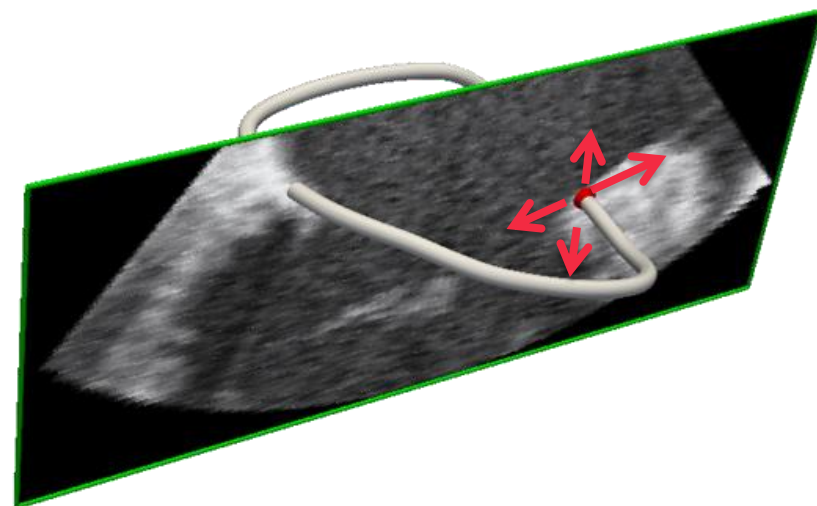
Internal Force

- Adjustments to anatomically plausible angles and point-distances



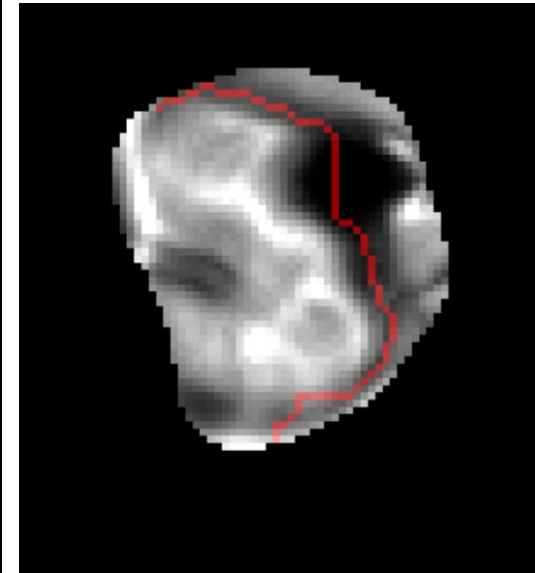
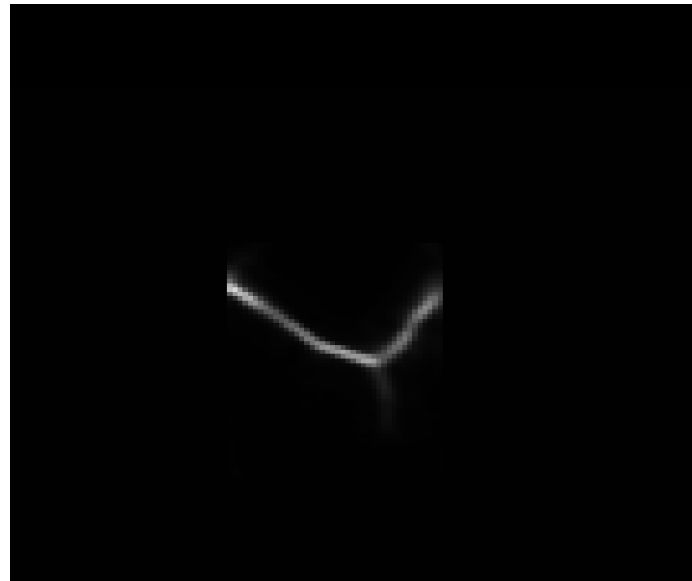
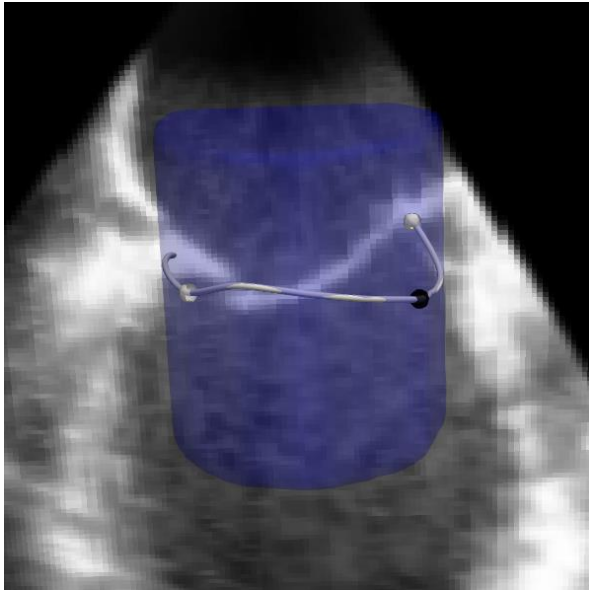
External Force

- Adjustment to image information



Valve Segmentation

Spatio-temporal mitral leaflets modelling

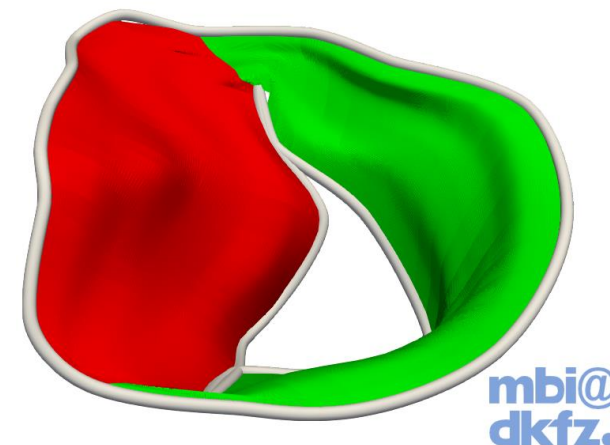
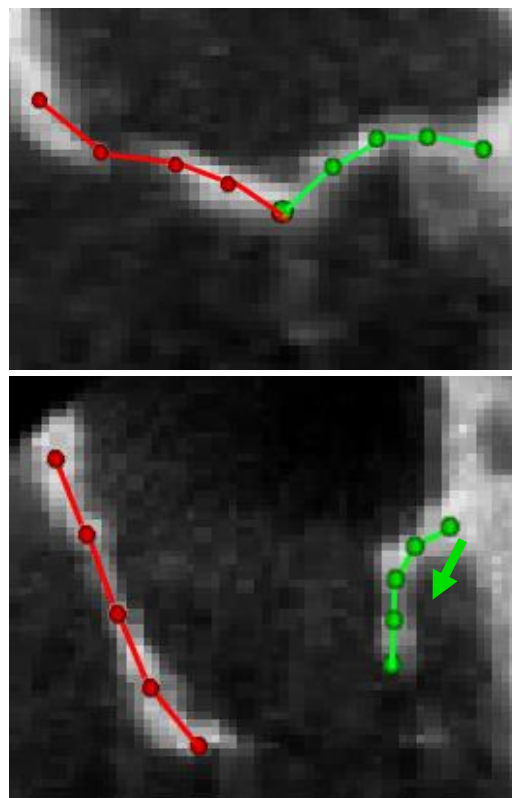
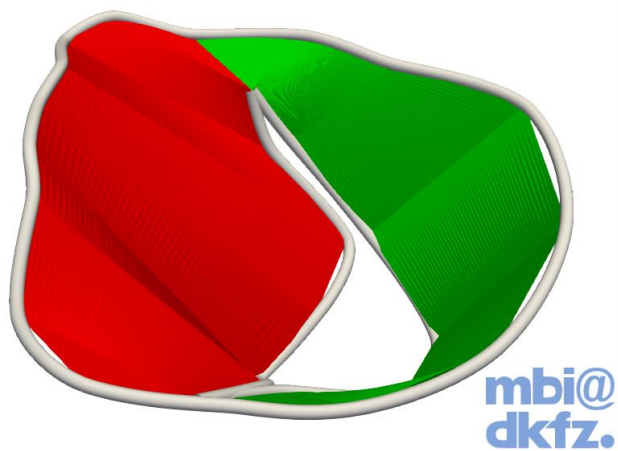


Region of Interest

Thin Tissue Detector

Leaflet Separation
Using Graph Cuts

Valve Segmentation



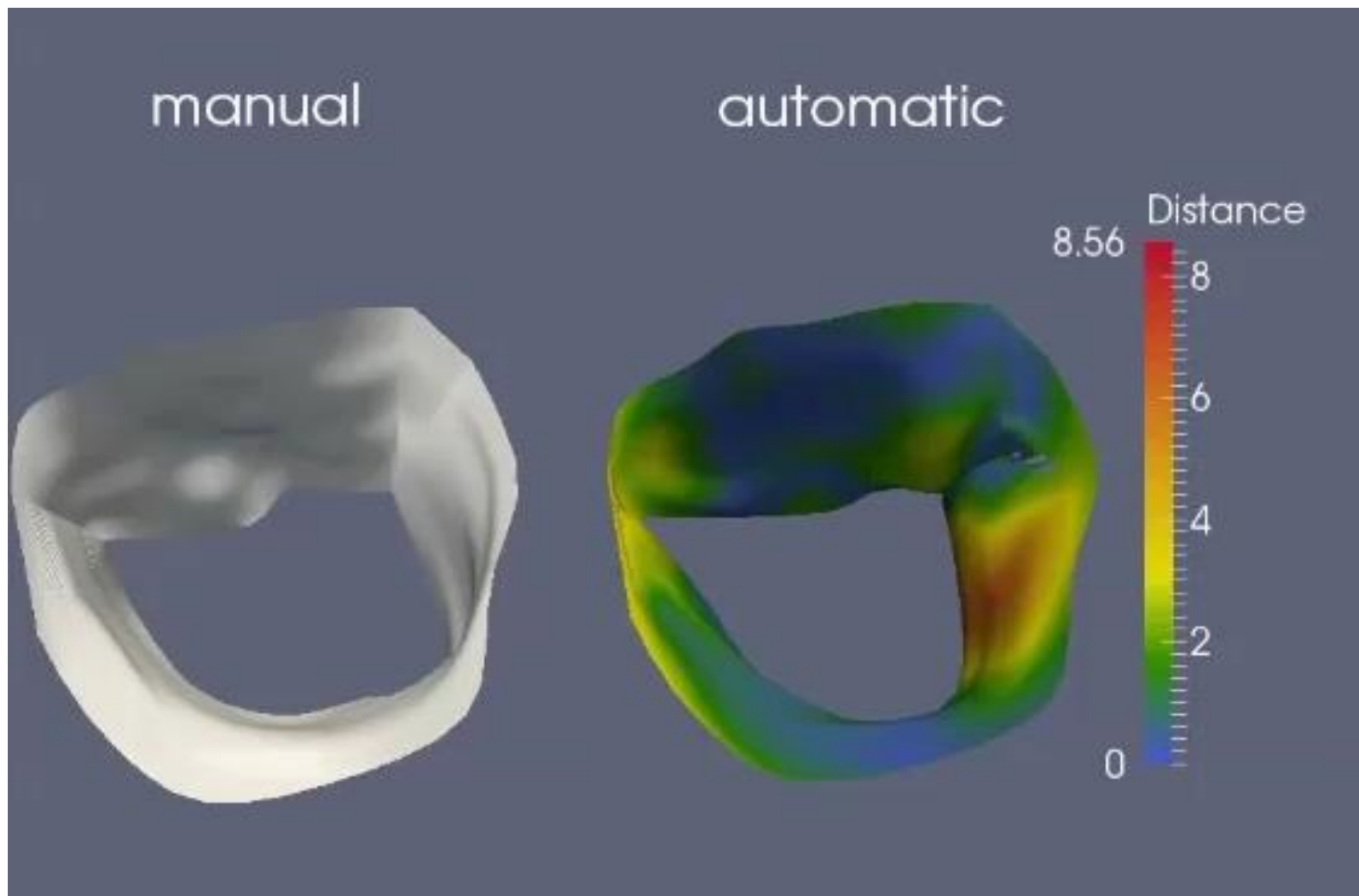
Model Initialization

Model Optimization
Over the Whole Cycle

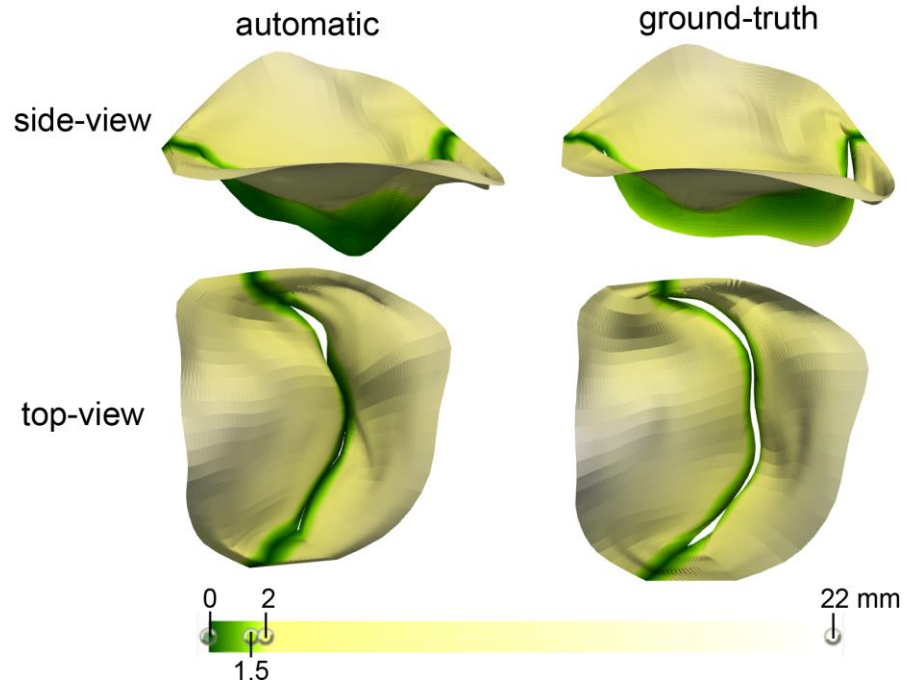
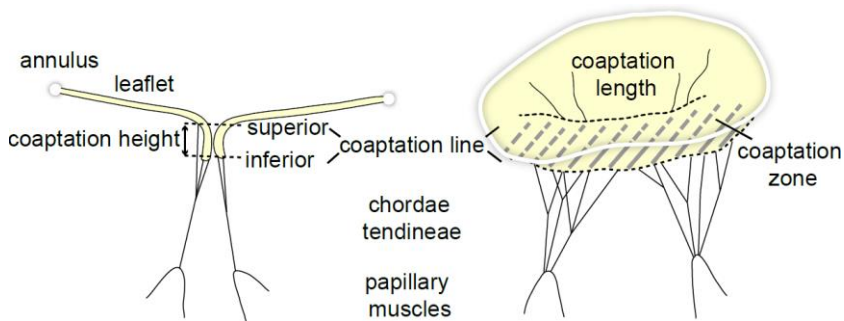
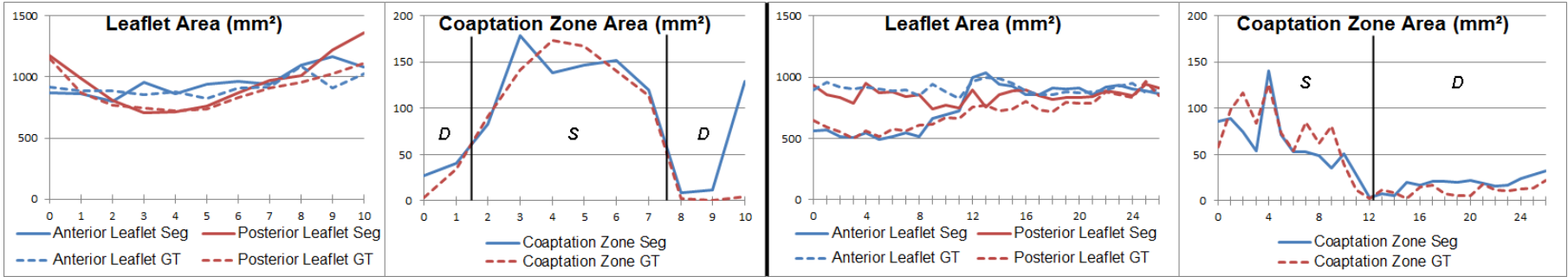
3D+t Mital Valve
Model

[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.

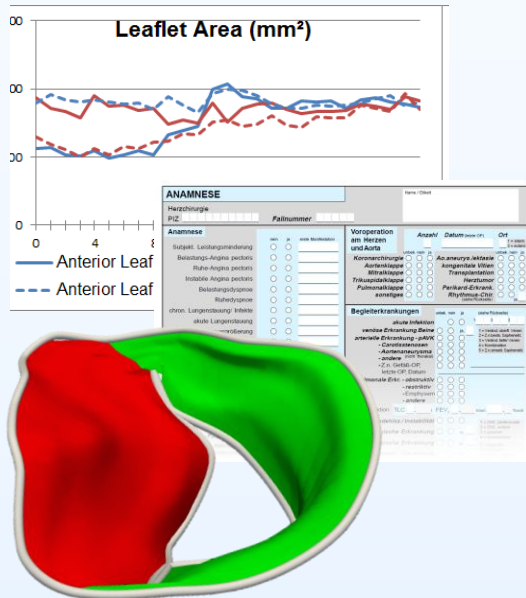
Valve Segmentation



Automatic Coaptation Zone Assessment

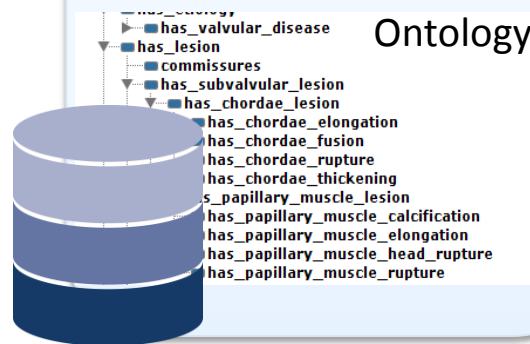


Perception



data acquisition
before, during and after surgery

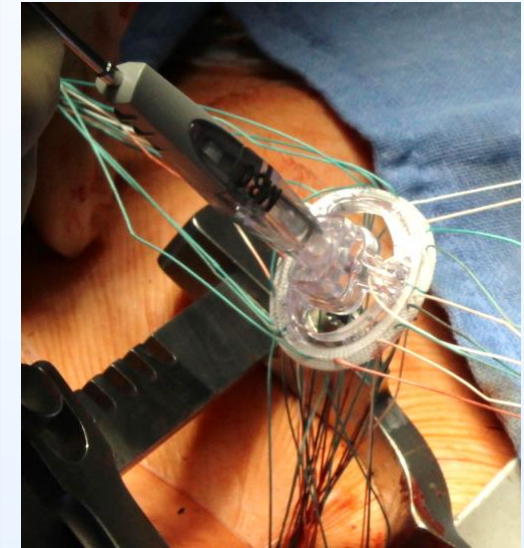
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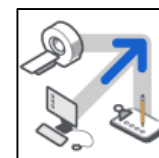
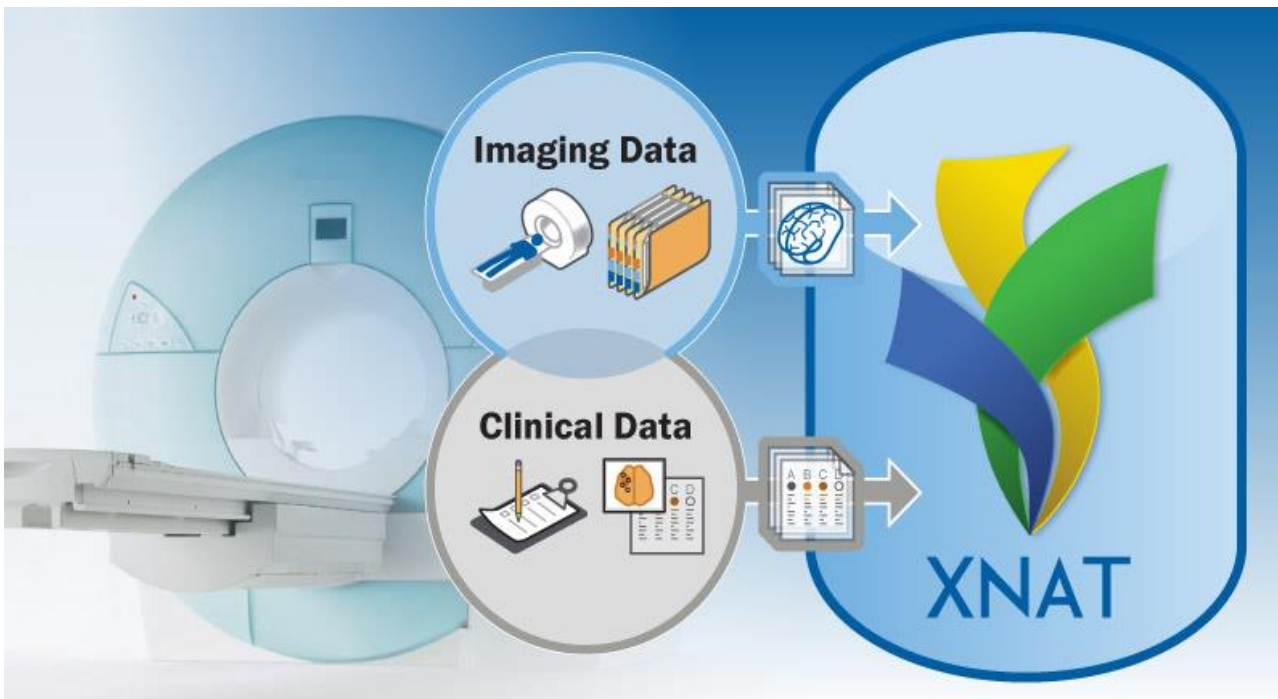
Action



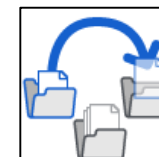
Annuloplasty ring selection

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

XNAT integration

Data Processing & Development in open-source MITK

The screenshot shows the MITK (Medical Image Toolkit) interface. At the top is a toolbar with icons for Open, Save Project, Close Project, Undo, Redo, DICOM, XNAT, and Image Navigator. Below the toolbar is a 'Display' window showing four panels: a top-left panel with a 3D model of a mitral valve, a top-right panel with a 2D ultrasound image, a bottom-left panel with a 2D image of a leaflet, and a bottom-right panel with a 3D segmented model of the mitral valve. A 'MITK' logo is overlaid on the bottom-left panel. To the right of the display is the 'XNAT Tree Browser' window, which shows a hierarchical tree structure of XNAT data. The tree includes folders like 'Cognitive Apps - Use Cases', 'Test Project', 'S01 Test', 'XNAT Example Project', and 'A02 - Cognition Guided Liver S...'. Under 'A02', there is a folder '0001' containing '01', 'Scans', and 'data'. The 'tee.nrrd' file is selected and highlighted in blue. Below the tree is a database icon and the XNAT logo. At the bottom of the interface, a status bar shows: 'Position: <44.35, 47.16, 20.88> mm; Index: <104, 112, 103>; Time: 0.00 ms; Pixelvalue: 66.00 5.23 GB (65.38 %)'.

XNAT Tree Browser Plugin

<is derived from>

<type description>



MitralValveSegmentation

The mitral valve model obtained from the segmentation in MITK consists of the anterior and posterior leaflets, the papillary muscles and the annulus.

Different quantifications can be obtained from it:

- Commissural Distance
- Chordae Length
- Area Anterior Leaflet
- Area Posterior Leaflet

Facts about "MitralValveSegmentation" RDF feed

Has property Property:Has Commissural Distance + \mathbb{R} , Property:Has Chordae Length + \mathbb{R} , Property:Has Area of Anterior Leaflet + \mathbb{R} , and Property:Has Area of Posterior Leaflet + \mathbb{R}

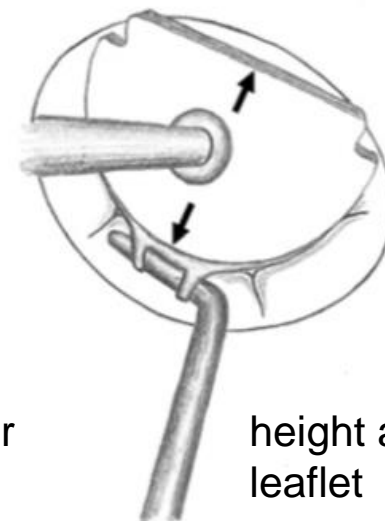
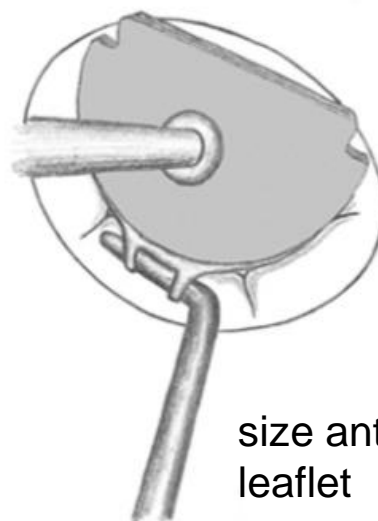
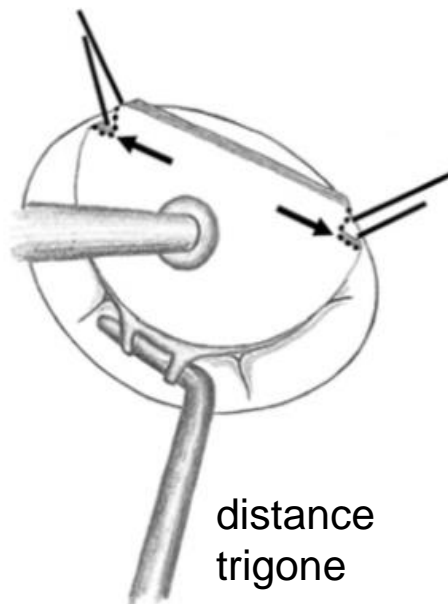
Semantic Representation

Intraoperative Valve Analysis

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

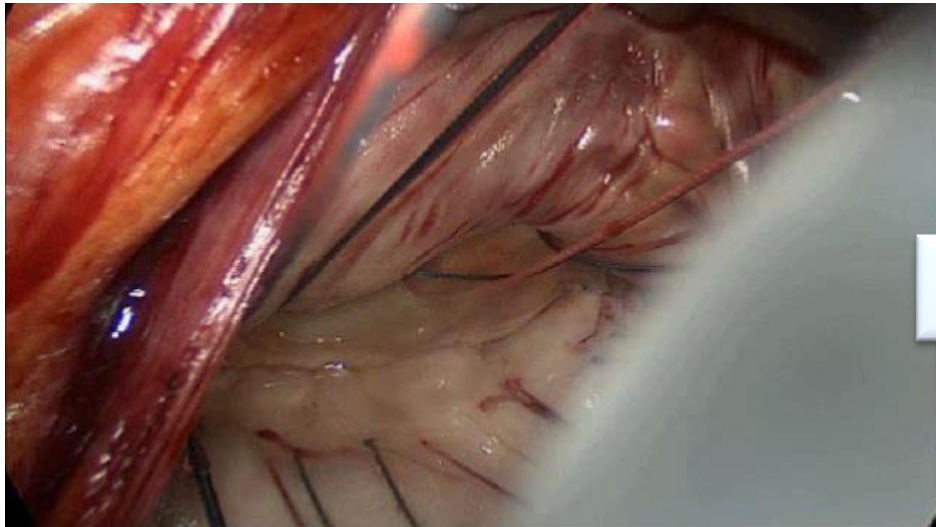
Wolfgang Bothe, MD, D. Craig Miller, MD, and Torsten Doenst, MD

- ▶ **Problem: no standardized approach!**
⇒ variability of methods & results



Intraoperative Valve Analysis

Visual assessment performed by the surgeon:
annuloplasty ring sizing with “sizer”



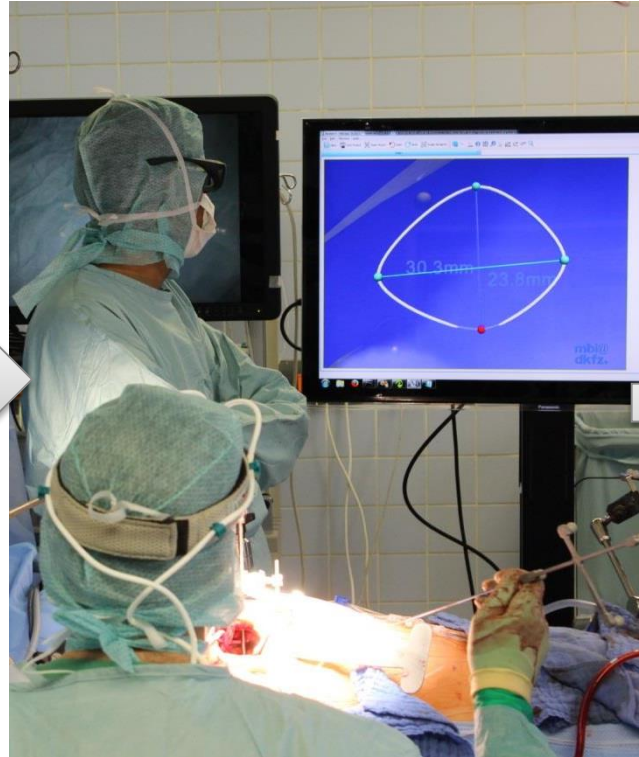
decision



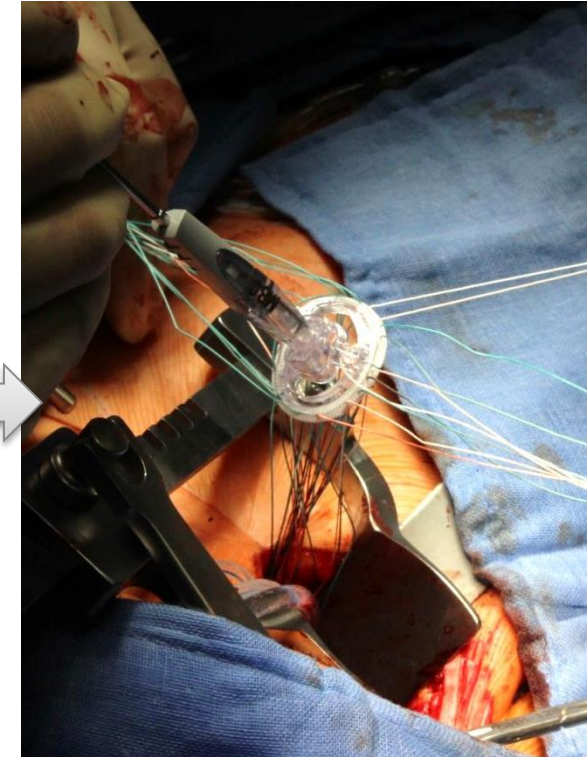
Intraoperative Decision Support



spatial measurements

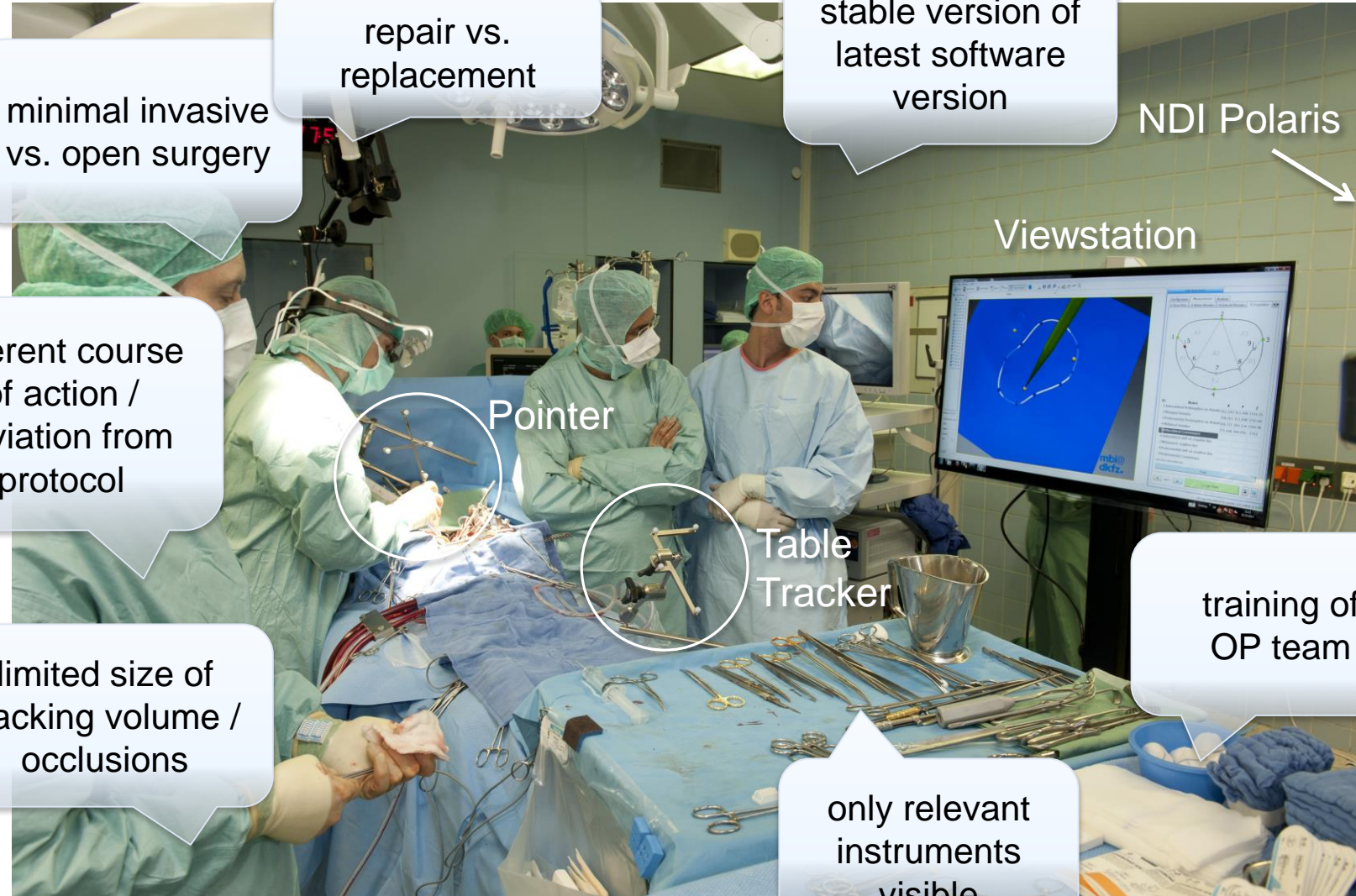


*visual guidance
& cognition-guided
decision support*



ring implantation

Intraoperative Decision Support



minimal invasive
vs. open surgery

repair vs.
replacement

stable version of
latest software
version

NDI Polaris

Viewstation

different course
of action /
deviation from
protocol

Pointer

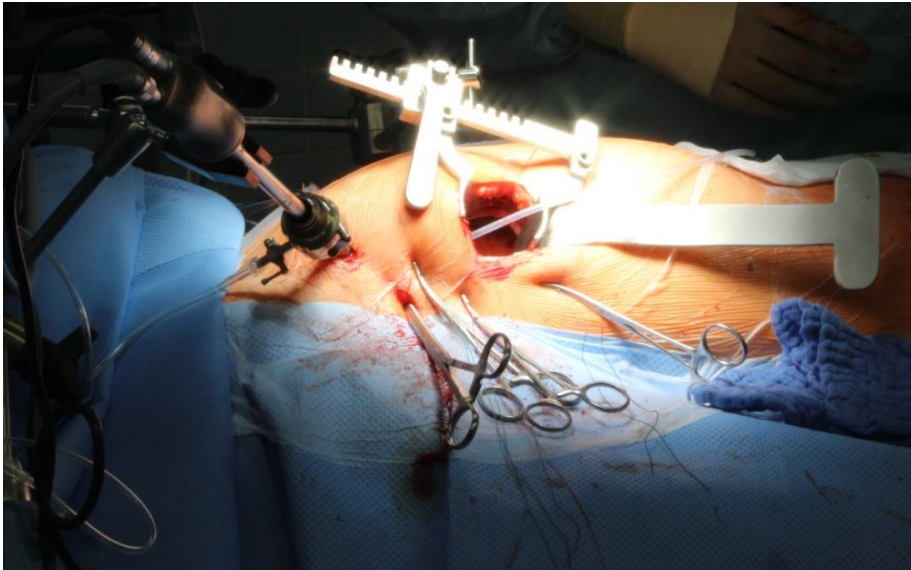
Table
Tracker

limited size of
tracking volume /
occlusions

training of
OP team

only relevant
instruments
visible

Application of the intraoperative assistance system (4 x) :



1x minimal invasive mitral valve reconstruction



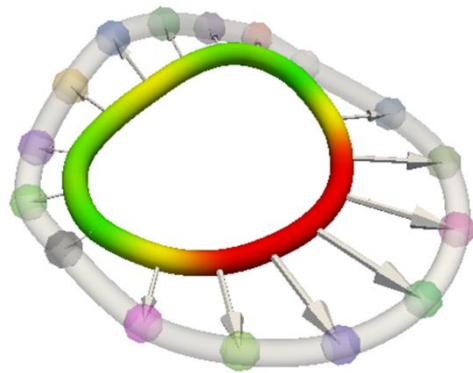
2x open mitral valve replacement
1x open mitral valve reconstruction



Mille grazie!

Raffaele De Simone Sandy Engelhardt

UNIVERSITÄT
HEIDELBERG
Zukunft. Seit 1386.



Cognition-Guided
Surgery 

