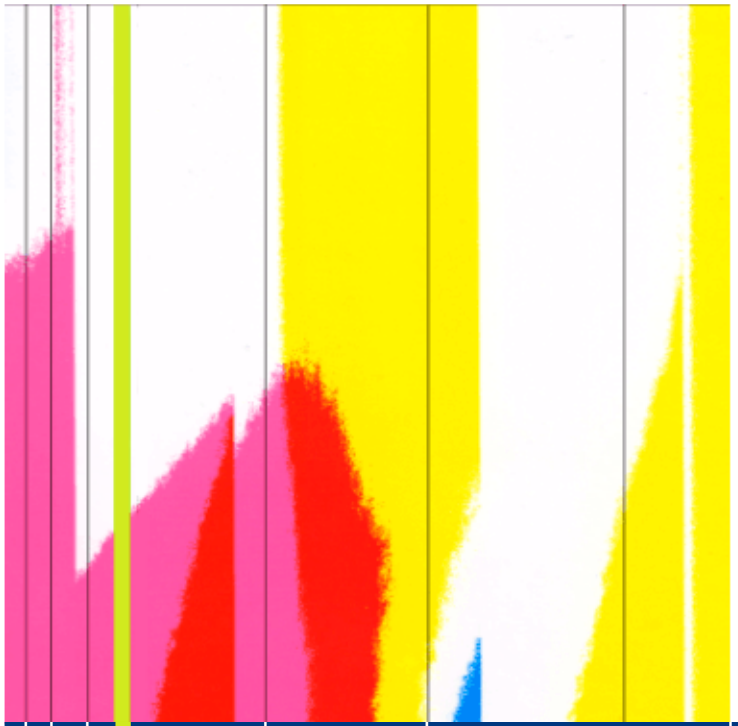


Asclepios Research

H. Delingette & M. Sermesant

Intermediate Evaluation of the CardioSense3D Research Action

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

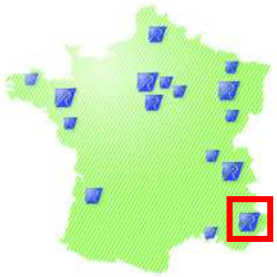
INRIA

CS3D

Asclepios Team

Researcher Scientists:

- Nicholas Ayache (Lead)
- Hervé Delingette
- Grégoire Malandain
- Xavier Pennec
- Maxime Sermesant
- Olivier Clatz



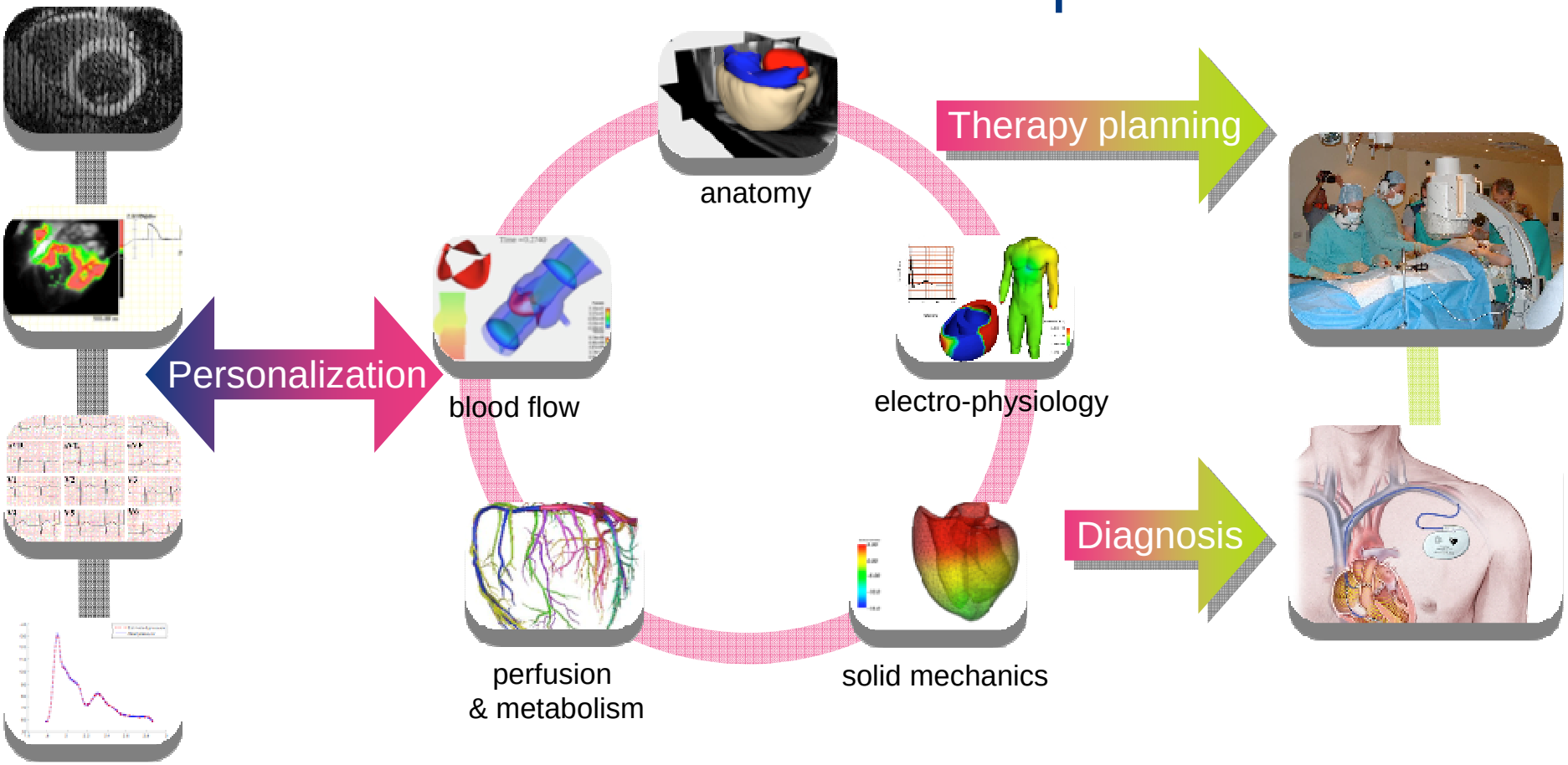
Team Scientific Focus

- Medical Image Analysis
- Computational Anatomy
- Computational Models of the Human Body
- Biomedical Imaging
- Clinical Evaluation and Validation

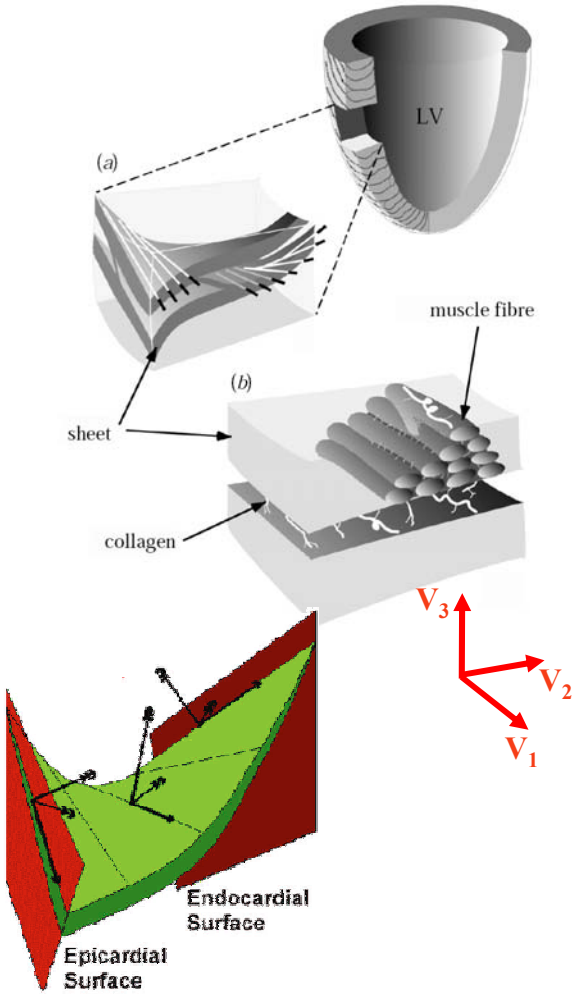
CardioSense3D Research in Asclepios

- Statistical Atlas of Cardiac Diffusion Tensor Imaging
- Cardiac Image Reconstruction Pipeline
- Parameter Estimation of Electrophysiology Models
- Towards the simulation of cardiac pathologies

CardioSense3D Research Topics



Cardiac Microstructure [LeGrice,1995]



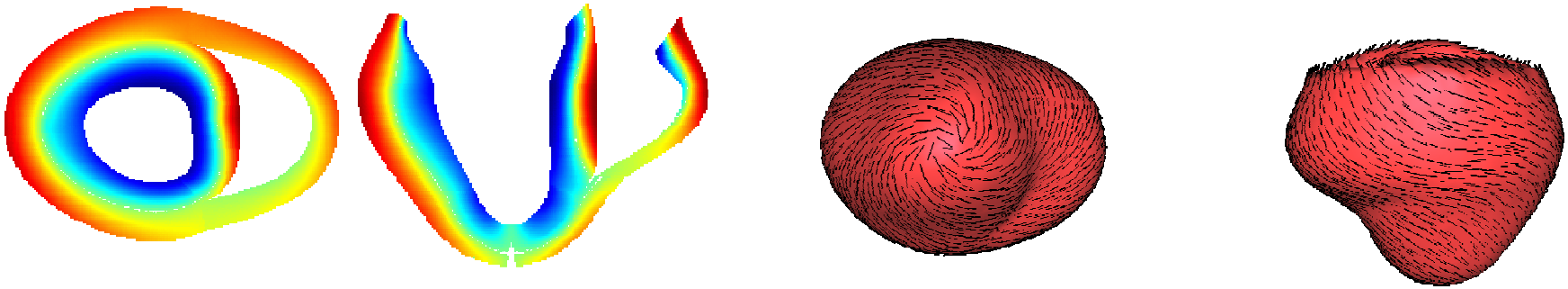
- Myocardial fibers
- Laminar sheets

- Play an important role in cardiac modeling (Electrophysiology, mechanics)

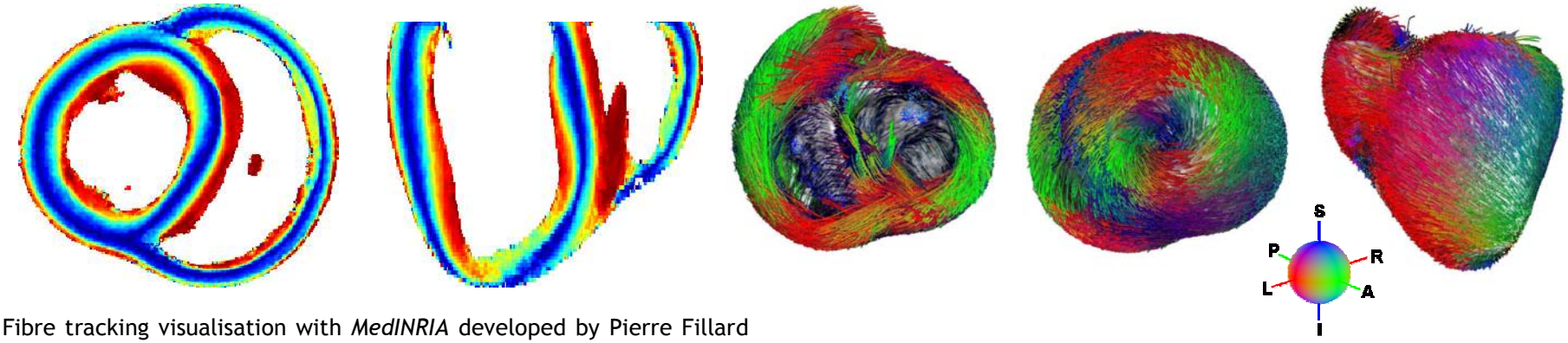
  - Correlation with DTI eigenvectors [Scollan,1998] [Helm,2005]
    - primary as fiber orientation
    - secondary as orthogonal to fibres in the sheet plane
    - tertiary as normal to sheet plane

Observations of Cardiac Architecture

Dissection *(P. Hunter group, Auckland University, New Zealand)*



Diffusion Tensor MR *(NIH, JHU. Mean tensors: J-M Peyrat)*

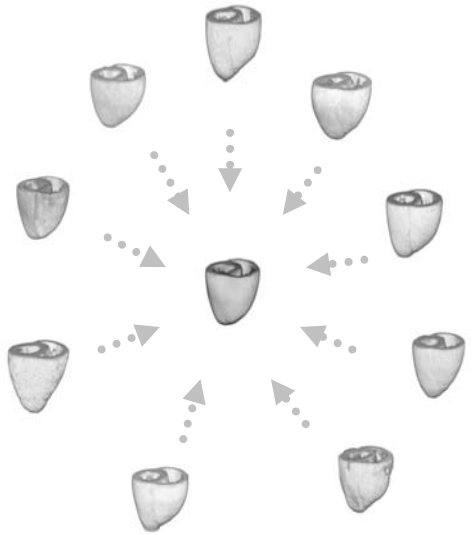


Fibre tracking visualisation with *MedINRIA* developed by Pierre Fillard and Nicolas Toussaint, INRIA, Asclepios.

Statistical Atlas of cardiac DTI

Based on 9 canine hearts (E. McVeigh, NIH, JHU)

Diffusion tensor MRI Registered in a common anatomical frame



Previous Work : atlas based on scalar values [Helm, 2005]

Main Issues :

- Non-linear Registration
- Tensor reorientation
- Tensors are not in a vectorial space!!!

J.M. Peyrat, M. Sermesant, X. Pennec, H. Delingette, C. Xu, E. McVeigh, N. Ayache, MICCAI, Oct 2006

Statistical Framework

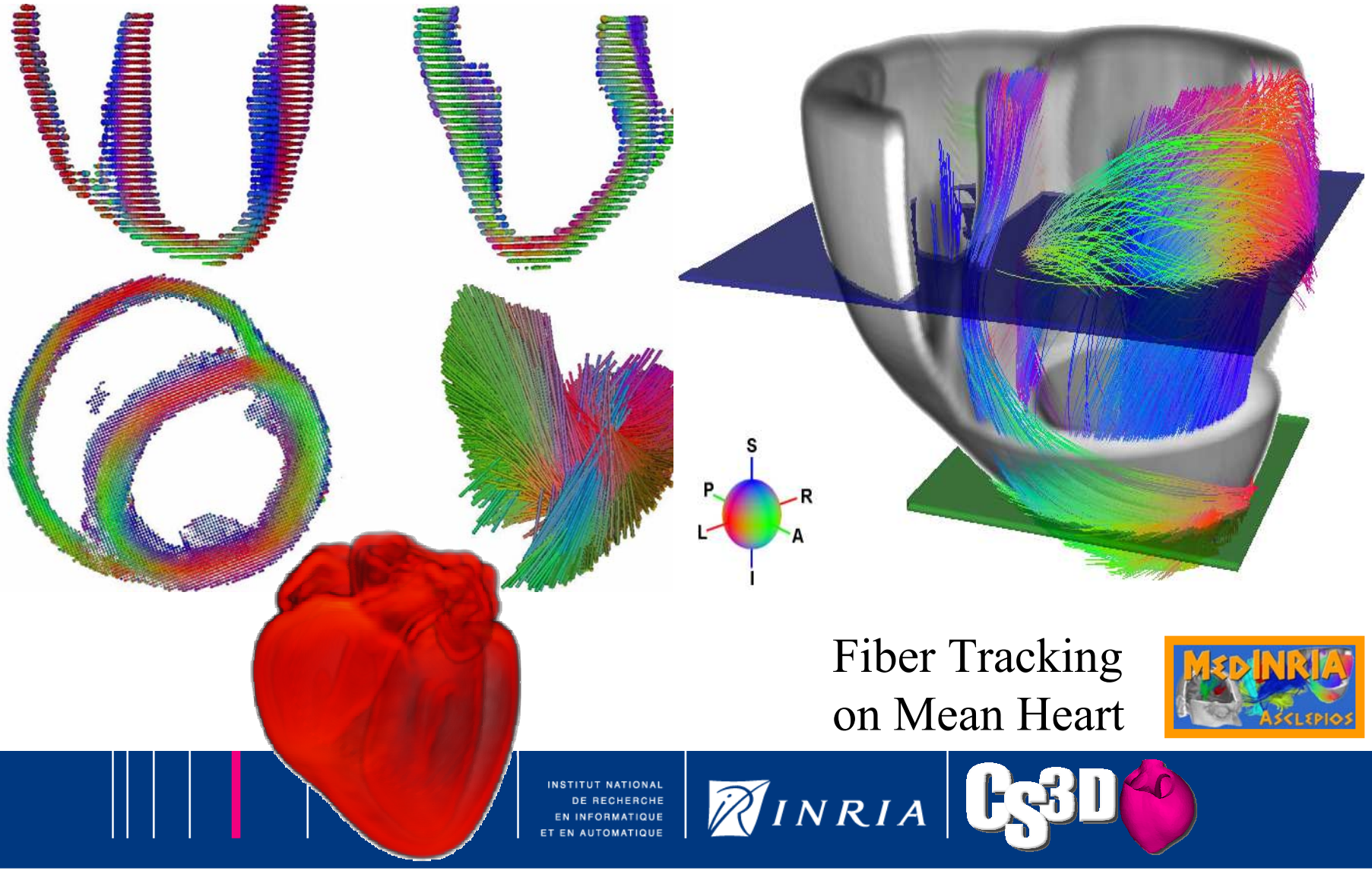
- Log-Euclidean framework : DTI space is a vectorial space
- Mean DTI Model :

$$\overline{D} = \exp\left(\frac{1}{N} \sum_i \log(D_i) \right)$$

- Covariance (6x6 matrix) :

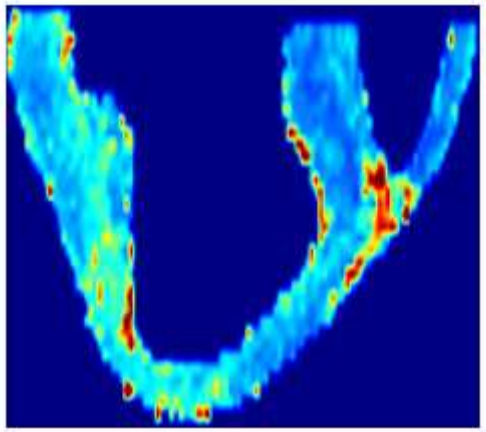
$$Cov = \frac{1}{N-1} \sum_i \left(Vec\left(\log(D_i) - \log(\overline{D}) \right) \right)^T Vec\left(\log(D_i) - \log(\overline{D}) \right)$$

Mean Canine Heart (Shape + Tensor)



Fiber Tracking
on Mean Heart

Variability of Cardiac Structures



Covariance Computed in the Log-Euclidean Metrics

Primary eigenvector

Secondary eigenvector

Tertiary eigenvector

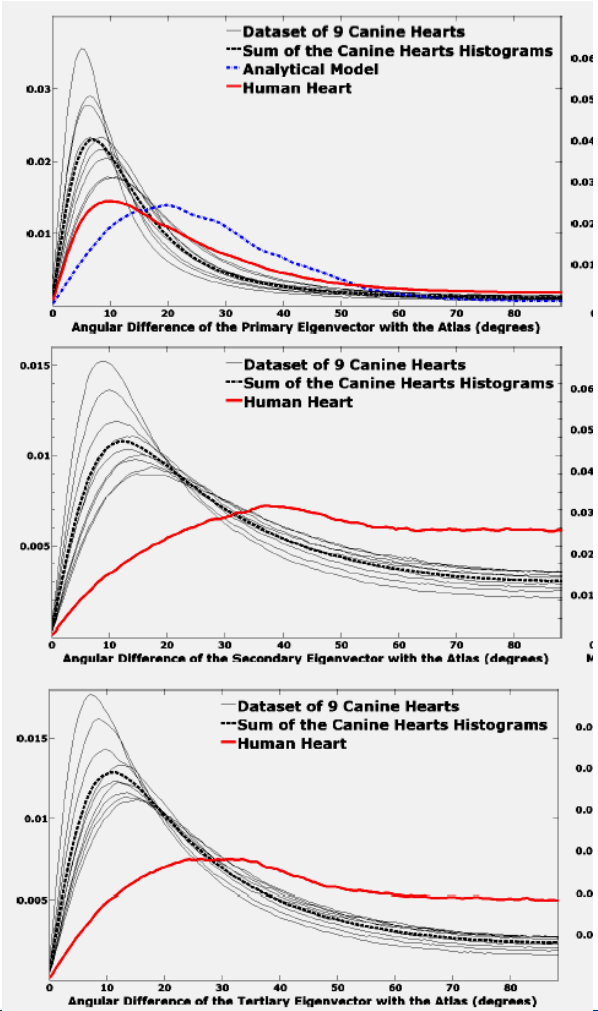


Fig. 6. [*Left Column*] Normalized histogram
eigenvectors variations around their mean. [*R*
primary, secondary and tertiary eigenvectors

J.M. Peyrat, M. Sermesant, X. Pennec, H. Delingette, C. Xu, E. McVeigh, N. Ayache, MICCAI, Oct 2006

Perspectives

- Use extended image database of DT MRI,
- Study influence of Fiber Orientation variability on electrophysiology and mechanical simulations,
- Study the coupled statistics between myocardial shapes and architecture.

CardioSense3D Research in Asclepios

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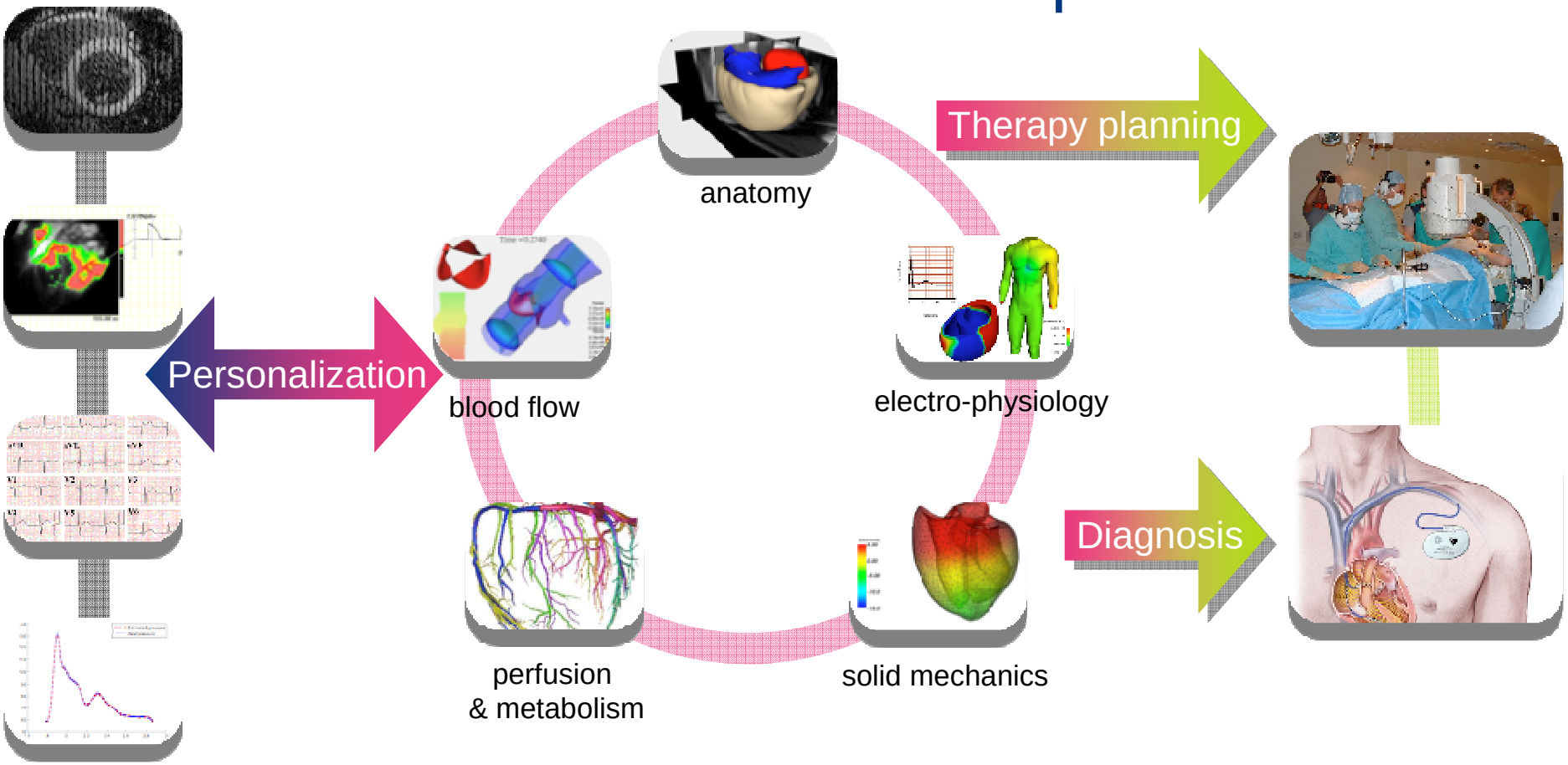
CardioSense3D Research Topics



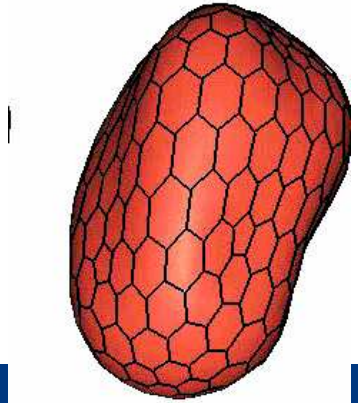
Geometric personalization from images

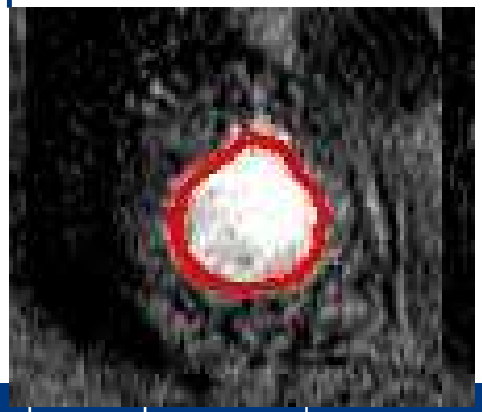
•3D and 4D Cardiac Imaging : cine-MR, tagged MRI, late-enhancement MR, 4D CT, 3D US,…

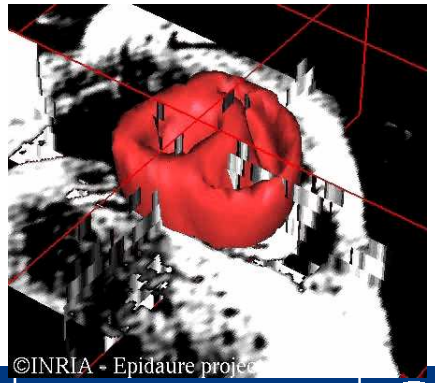
•Common Image Analysis problems :

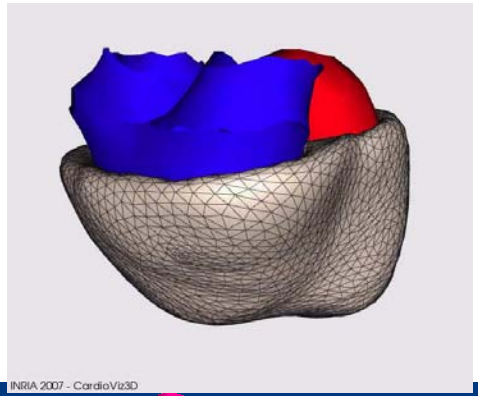
- Image Segmentation : myocardium, main vessels, scars,…
- Image Fusion : Xray-MRI, DT – MR Imaging
- Motion Tracking : myocardium,…

•Creation of Computational Meshes (surface, volumes,…) with labels and fiber specification





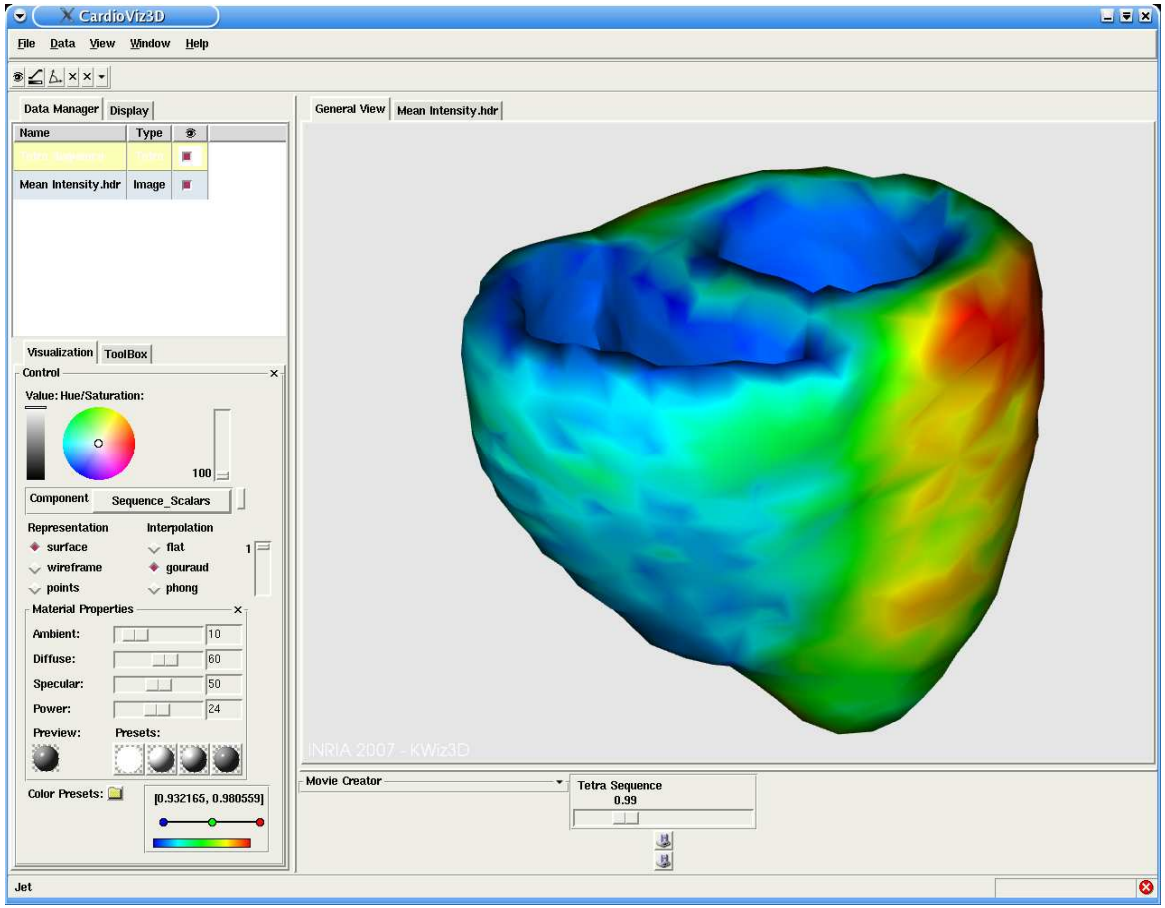




Integration of CardioViz3D Software

- Integrate cardiac image algorithms :
  - Thresholding / Mathematical Morphology algorithms
  - Deformable Simplex Meshes
    [J. Montagnat and H. Delingette. **4D Deformable Models with temporal constraints : application to 4D cardiac image segmentation**. *Medical Image Analysis*, 9(1):87-100, February 2005]
  - Non-linear Image Registration (Diffeomorphic Daemons)
    Tom Vercauteren, Xavier Pennec, Aymeric Perchant, and Nicholas Ayache. **Diffeomorphic Demons Using ITK's Finite Difference Solver Hierarchy**. In *Insight Journal -- ISC/NA-MIC Workshop on Open Science at MICCAI 2007*, October 2007
  - Interactive Segmentation tools
- Operational segmentation pipeline for cine-MR Images
- Powerful Visualization of time series of meshes / images with scalar, vectorial, tensorial fields
- Used to showcase CardioSense3D simulation results.

CardioViz3D Software



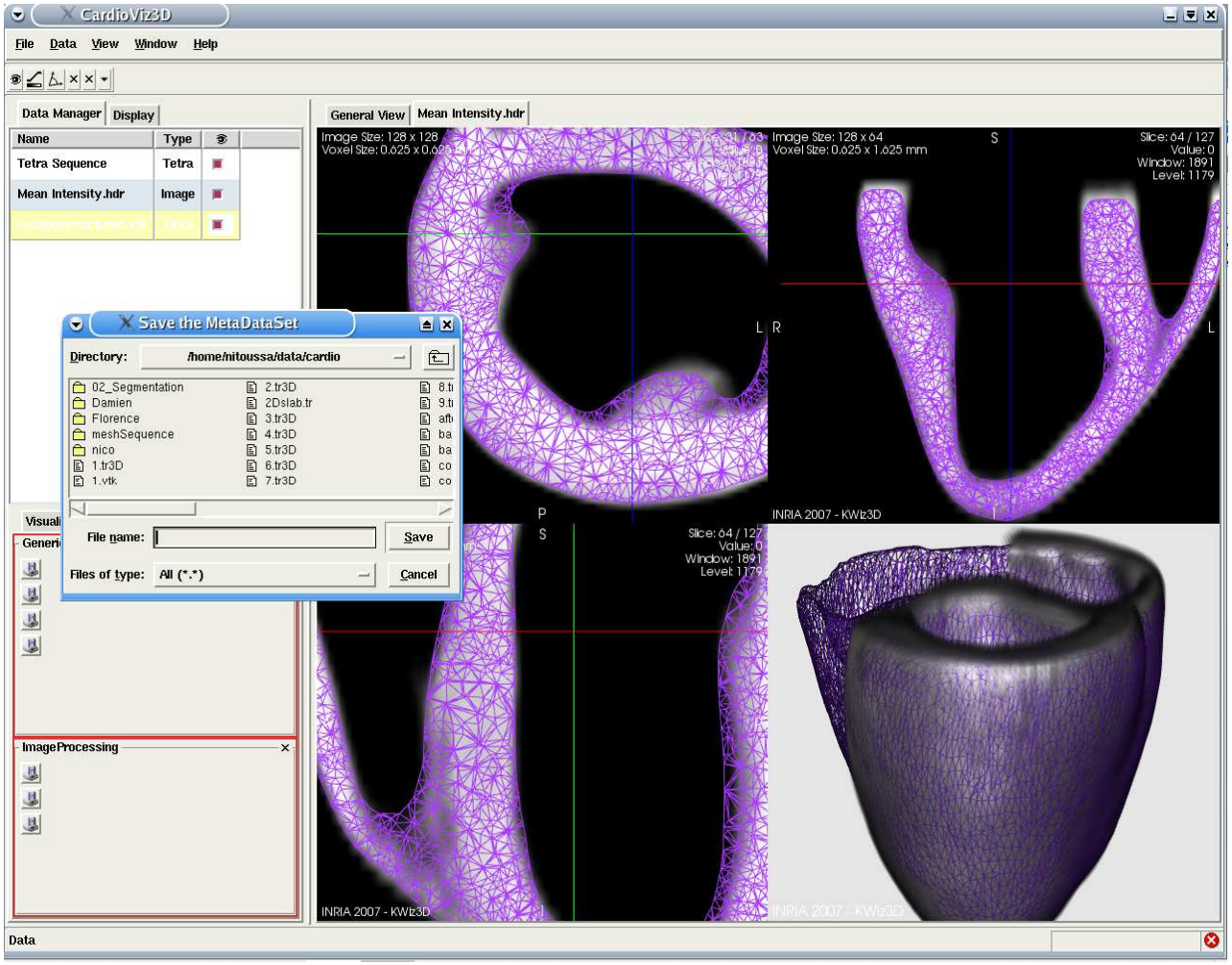
Built upon Open Source libraries

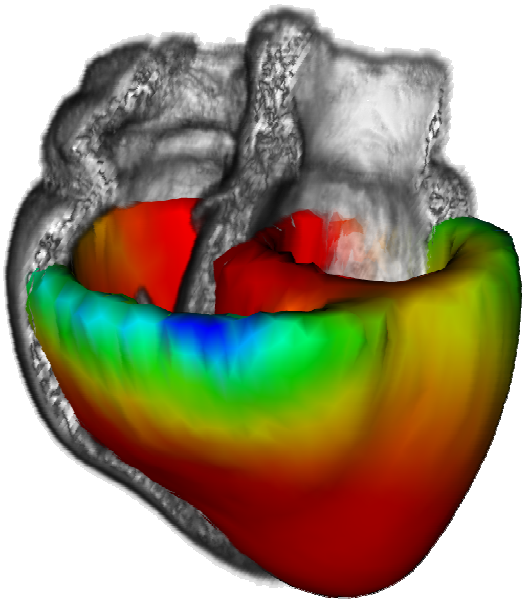
VTK, ITK, Mips, KwWidget, TCL

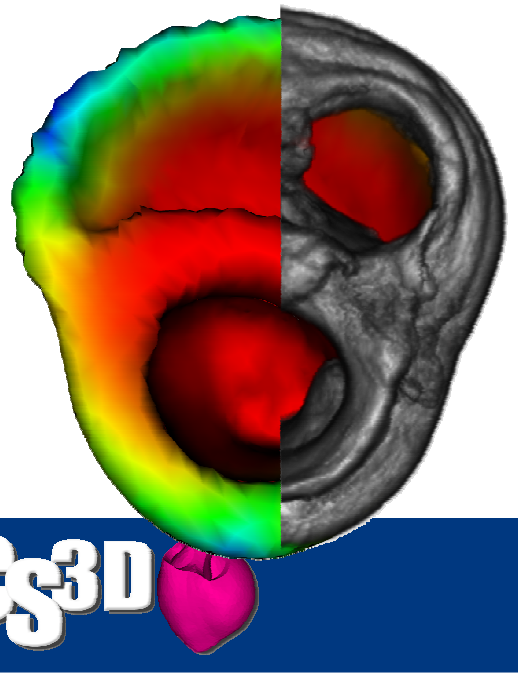
Publicly available at:

http://www-sop.inria.fr/asclepios/software/CardioViz3D

CardioViz3D Software







Perspectives

- Improve myocardium tracking by using biomechanical constraints (fiber orientation, incompressibility).
- Improve automatic fiber settings and labelling (AHA segments,…)
- Segment/ track tagged MR Imaging.
- Create synthesized images from electromechanical model