Scientific Projects: Heart Simulation

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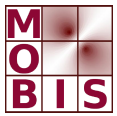


Graz/Styria: some numbers

- Austria/Styria: 8.7 Mill. / 1.2 Mill. inhabitants
- Graz: 282.000 (+325.000) part. including 50.000 students
- old city - beautiful city center
- south of the alps - north of the balkan

Graz/Styria: universities

- Karl-Franzens Universität (35)
- University of Technology (14)
- Medical University (5)
- Montan University at Leoben (5)

Members of the SCIENTIFIC COMPUTING Group

Head Univ.-Prof. Dipl.-Ing. Dr. Gundolf Haase

stDoc Mag.Dr. Manfred Liebmann(2016-, 2009-2015; PhD 2006-2009)

PhD Dipl.-Ing. Stefan Rosenberger (FWF: 2014-2018)

PhD MA Daniel Ganelleri; MA Alban Lumi

PhD MA Jana Fuchsberger (BTM 2017-2020)

laster Johanna Mayr (+ 3 in companies)

\+ Supervising 2 Ph.D. at companies + one at CERN

Cardiovascular Simulations

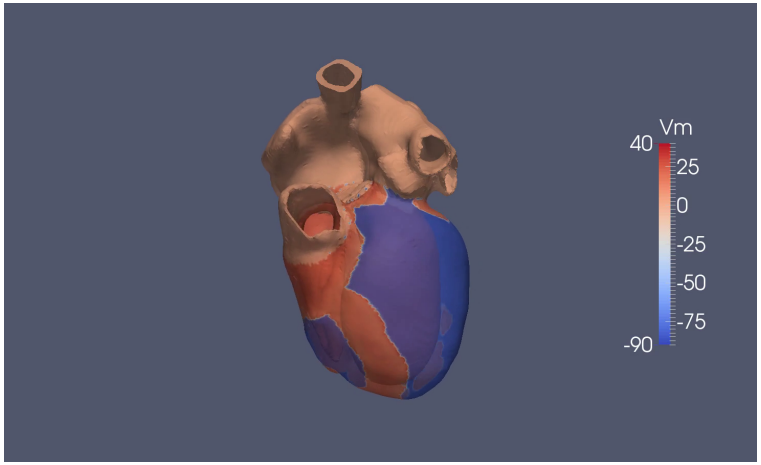
Bidomain equations:

$$-\nabla \cdot (\sigma_i + \sigma_e)\nabla u_e - \nabla \cdot \sigma_i \nabla v = I_e(t)$$

$$\nabla \cdot \sigma_i \nabla v + \nabla \cdot \sigma_i \nabla u_e = C_m \frac{\partial v}{\partial t} + I_{ion}(v, \mathbf{w})$$

$$\frac{\partial \mathbf{w}}{\partial t} = g(v, \mathbf{w})$$

- v: transmembran potential
- I_e: extracellular charge
- + nonlinear elasticity + CFD



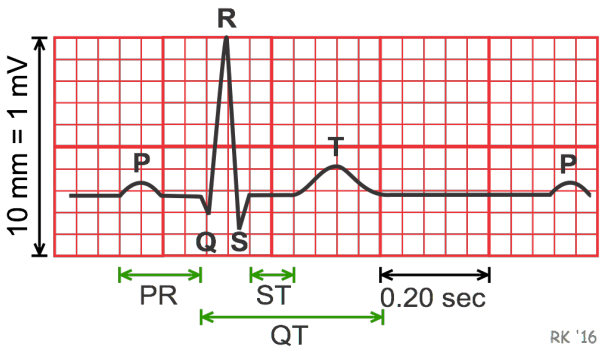
Patient specific simulations

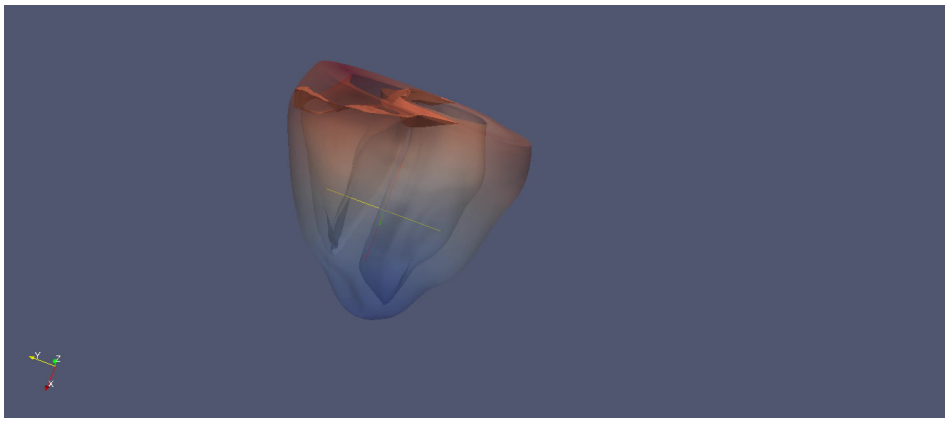
Tissue properties σ_i, σ_e in $-\nabla \cdot (\sigma_i + \sigma_e)\nabla u_e - \nabla \cdot \sigma_i \nabla v = I_e(t)$:

- a priori known values have a huge uncertainty
- in vivo measurements for σ_i, σ_e not possible with human
- tensor directions known from physiological maps

Compare calculated ECG with individually measured ECG:

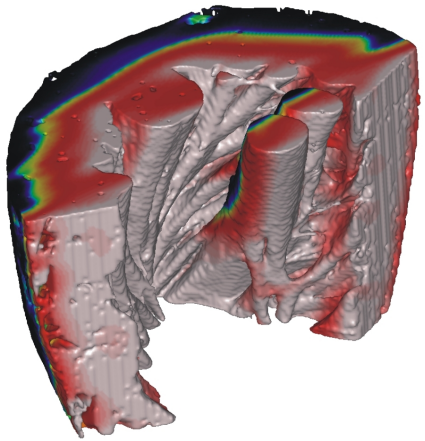
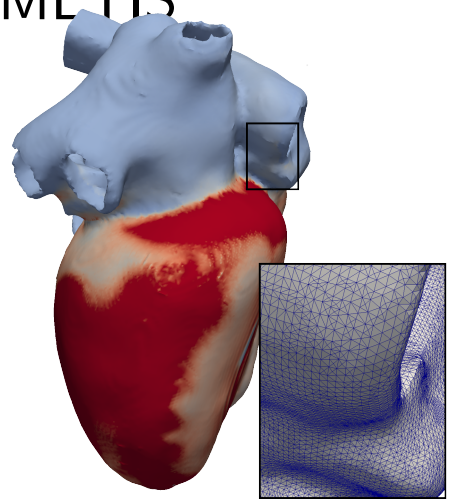
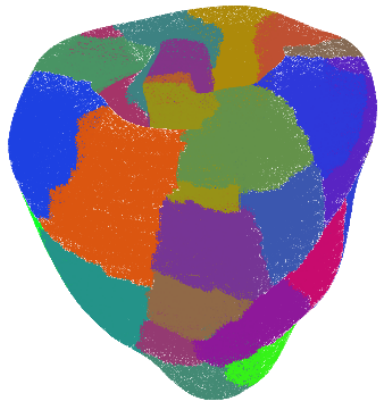
- Idea: Change $\sigma \rightarrow \sigma_{\text{patient}}$ s.t. $\text{ECG}_{calc} \rightarrow \text{ECG}_{meas}$
- By Means of Eikonal solver (excitation pattern)
  - Math. optimization
  - Deep learning





Rabbit Heart: Discretization

- Mesh generation by spider/tarantula [F. Kickinger]
- **Finite element** mesh with tetrahedral and hexahedral elements
- Mesh decomposition by METIS

- Solve linear system of equations (**That is our part!**)

$$Ku = f$$

in each outer (time/non–linear) iteration.

- System matrix K is sparse but unstructured.