In-Vivo Deformation Measurements of the Human Heart by 3D Digital Image Correlation

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Outline

- Background and Rationale
- Clinical tests at University Clinic at Marburg
- Results, discussion
- Conclusions

Motivation and Aims

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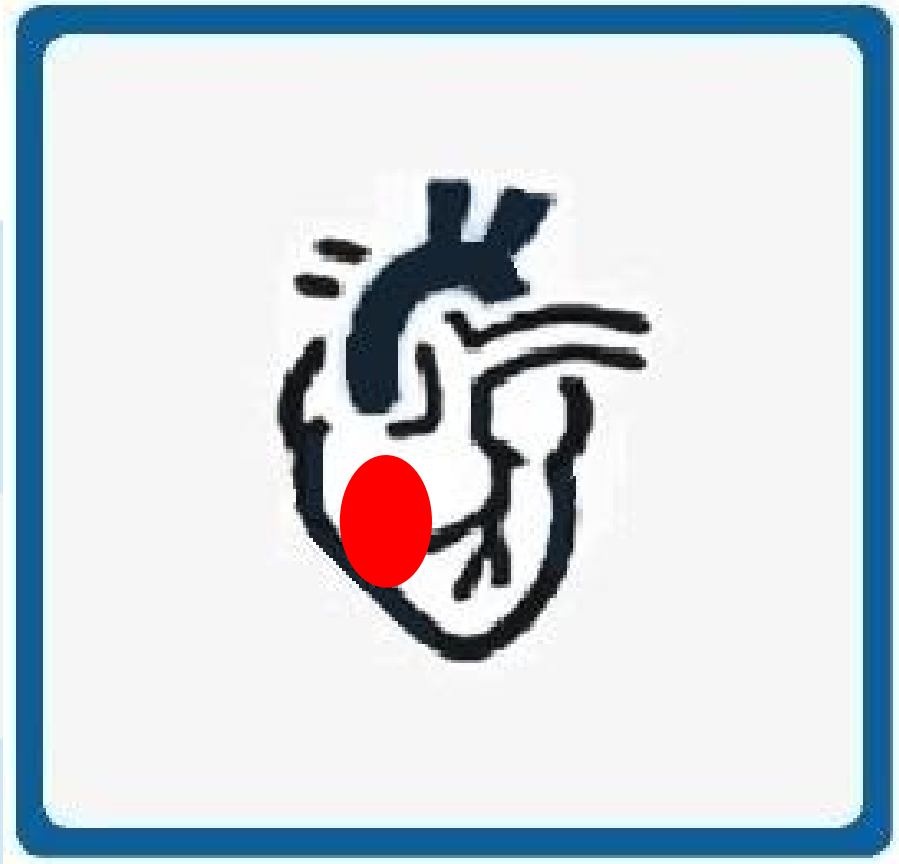


Current State-of-the-Art

- **Naked Eye**
- **Echocardiography**
- **X-Rays**
- **MRI**
- **Modeling**

Possible Problems and Risks

- **Infarction**
- **Intravasal volume control**
- **ECC Weaning**
- **Pulmonary hypertension**
- **ETC…**

Motivation and Aims

- Right side of the heart visible for photography
- Changes in the local motion and deformation of the heart can indicate a problem

- Can DIC be used for in-vivo measurement…?
- If yes, can it provide useful information…?

Measurements at Marburg University Hospital

Limitations of the clinical environment

- Setting up and calibration
- Lights
- Pattern
- Processing of images

Setting up and calibration

Setup and calibration

- StrainMaster Portable
  - Imager E-Lite 5MPix
  - OR lights
- Davis v.8.20

Calibration procedure

- Correcting the Z-level
  - Iterative process
- Final calibration
  - Pixel size 146.7 µm
  - STD 0.46 pixels

Image Quality - Day 1

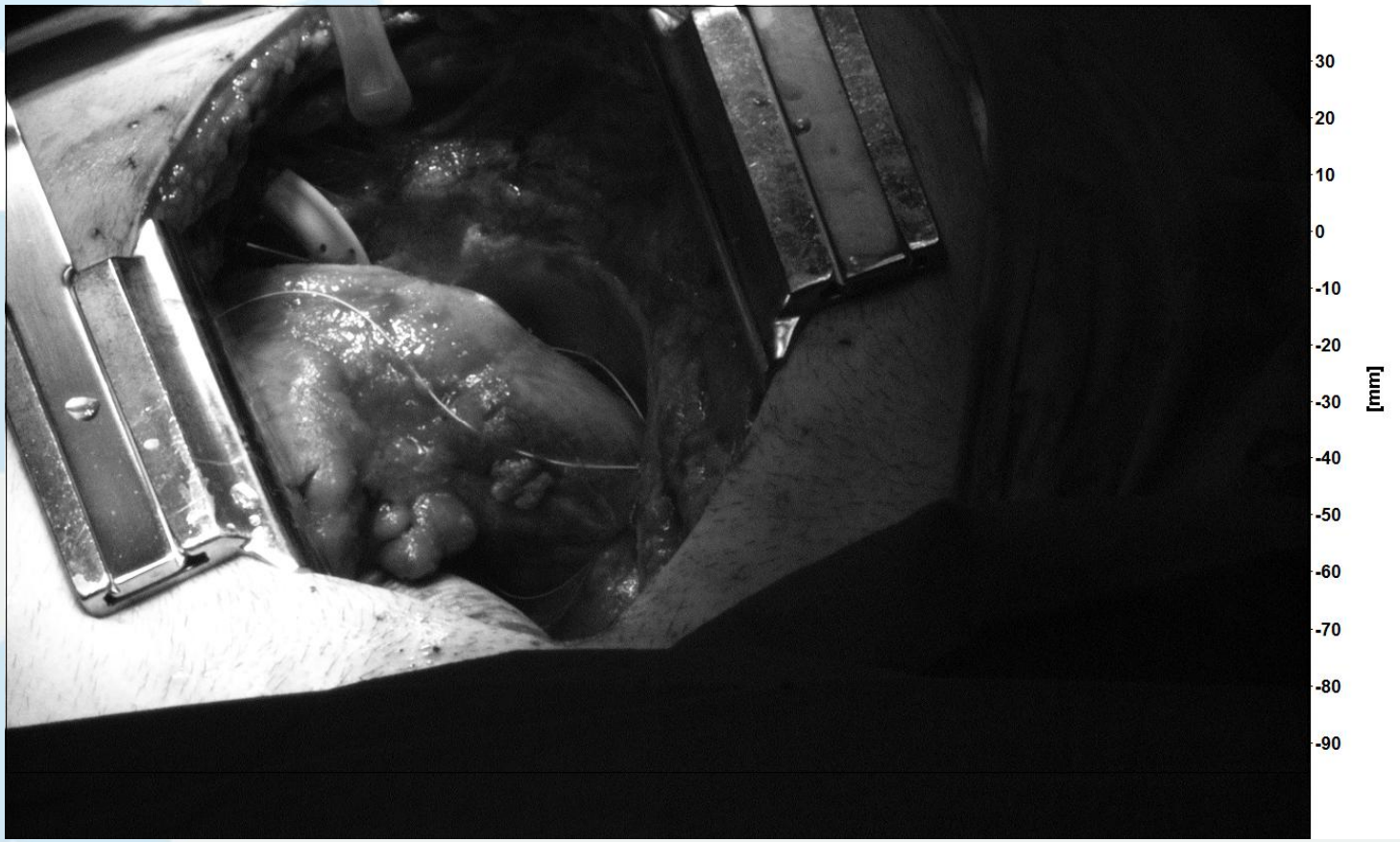


Image Quality - Day 2

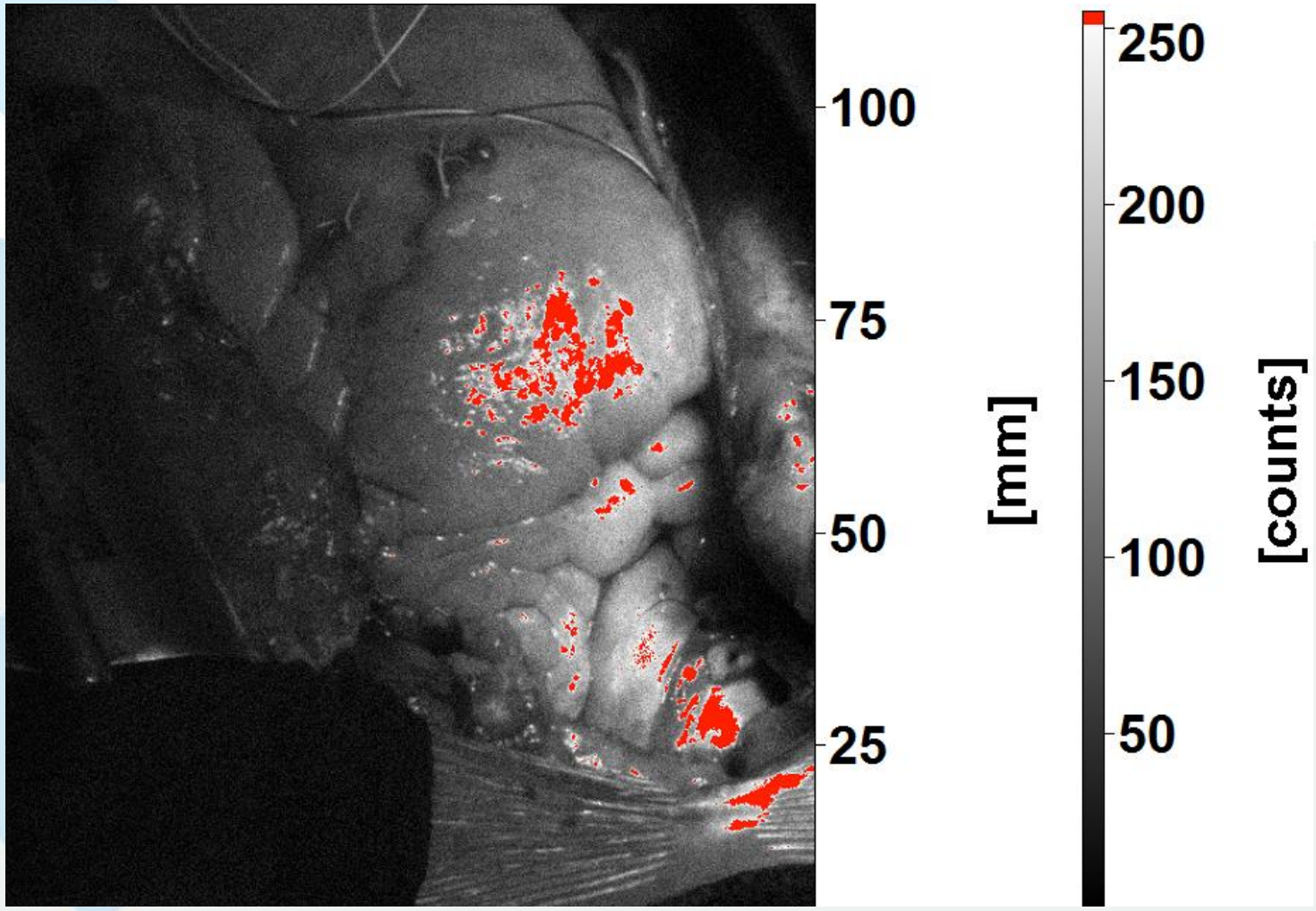
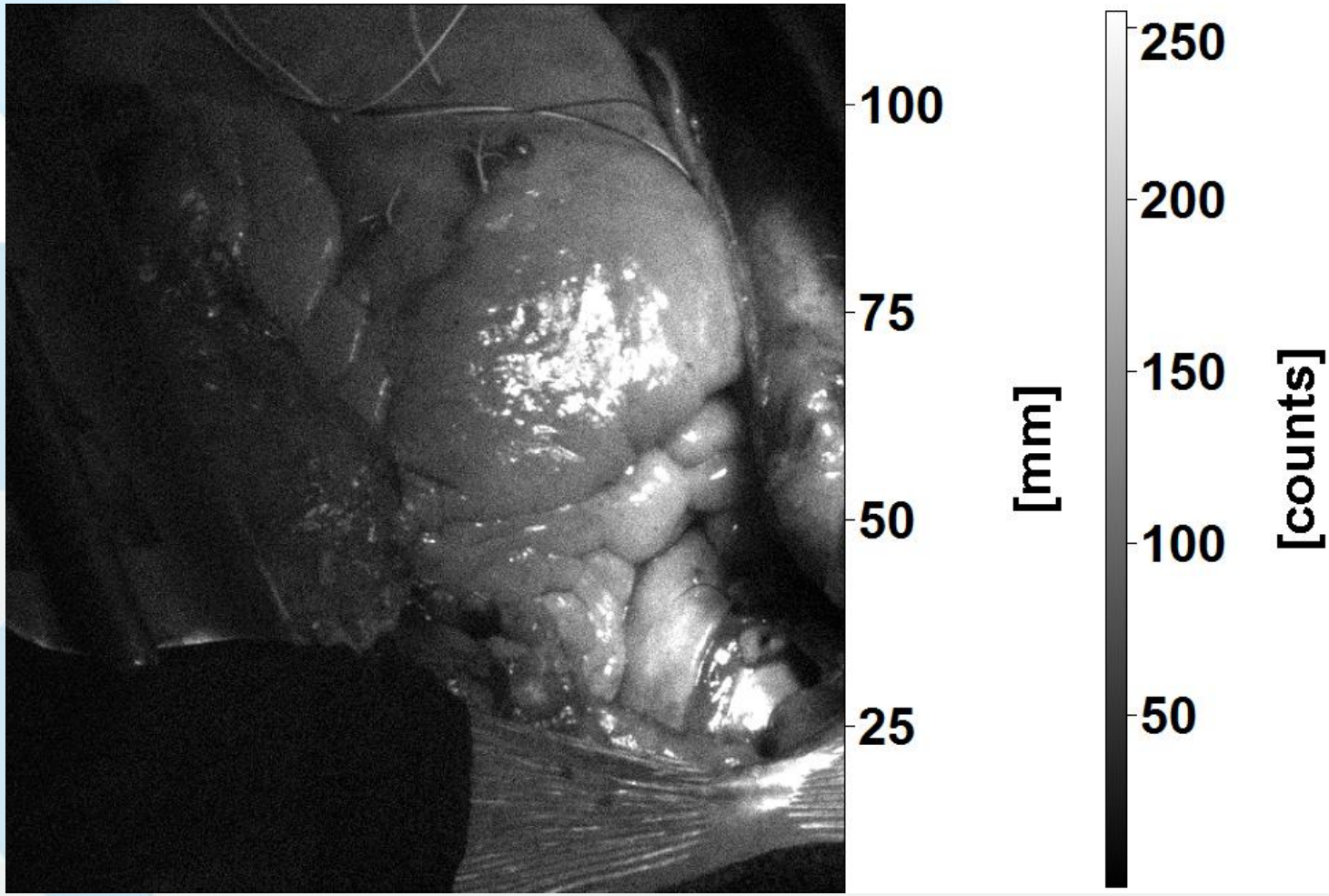
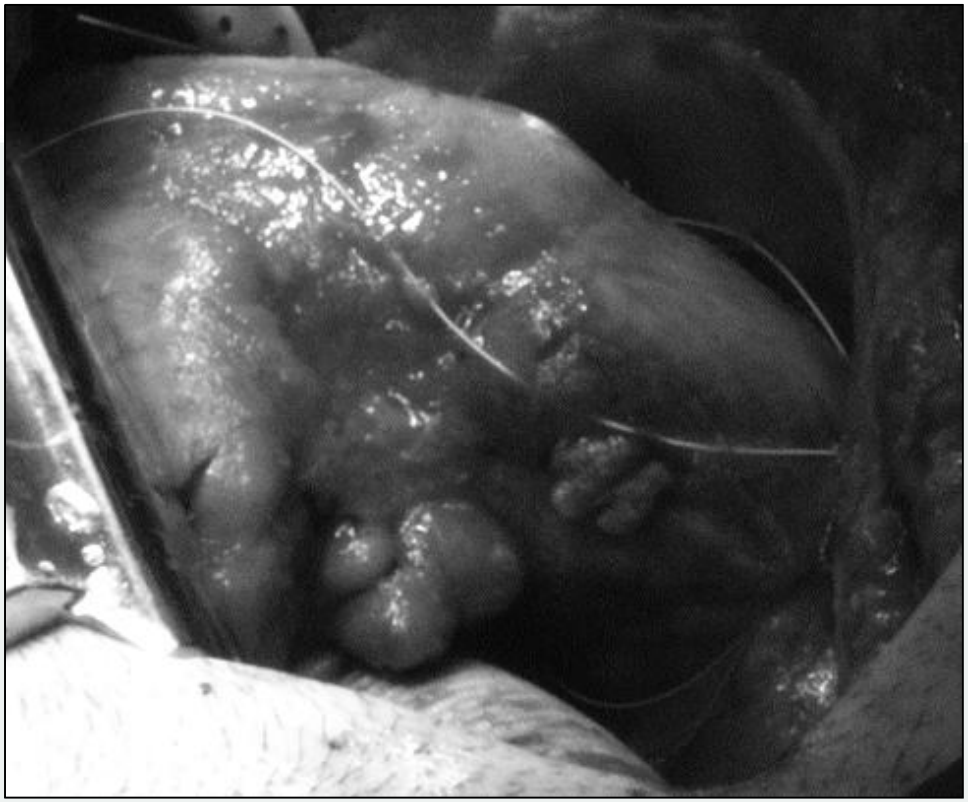


Image Quality – Day 2

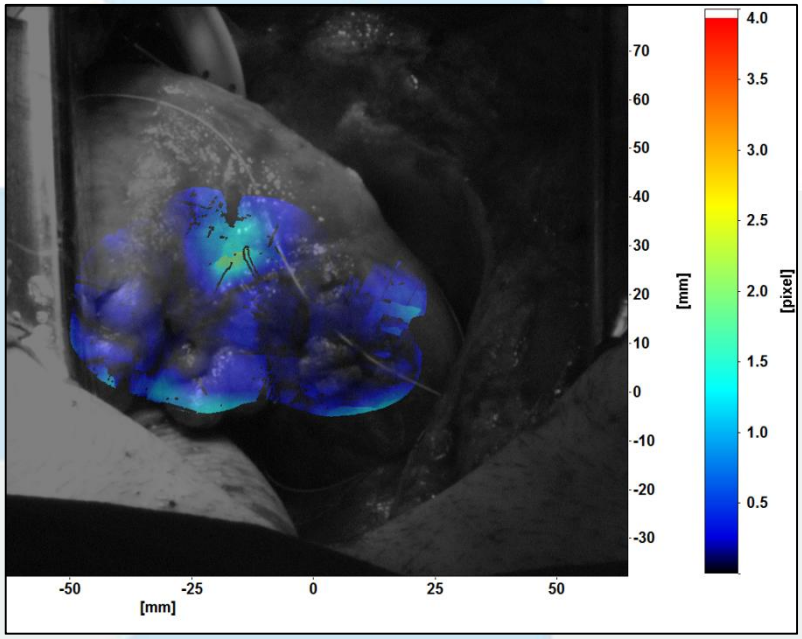


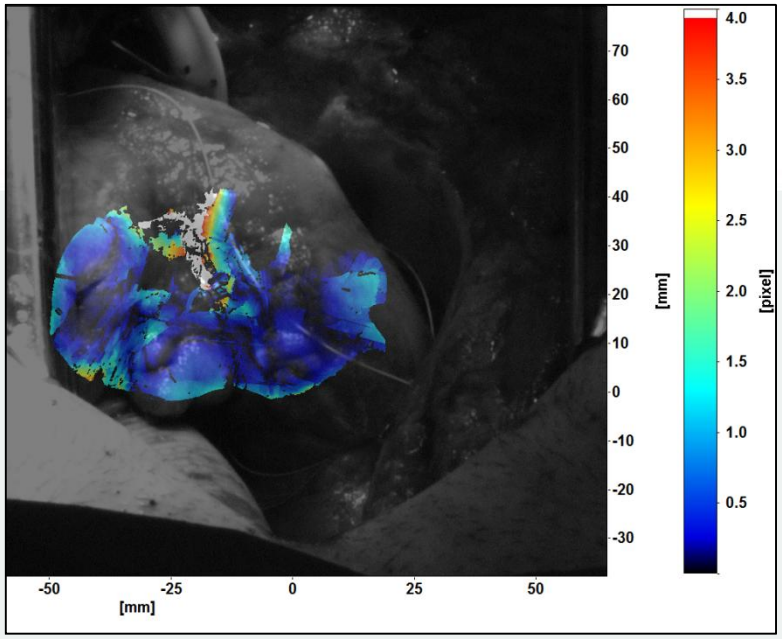
DIC Processing

- Area of Interest
- Subset size
  - 121 pixels
- Step size
  - 1 pixel

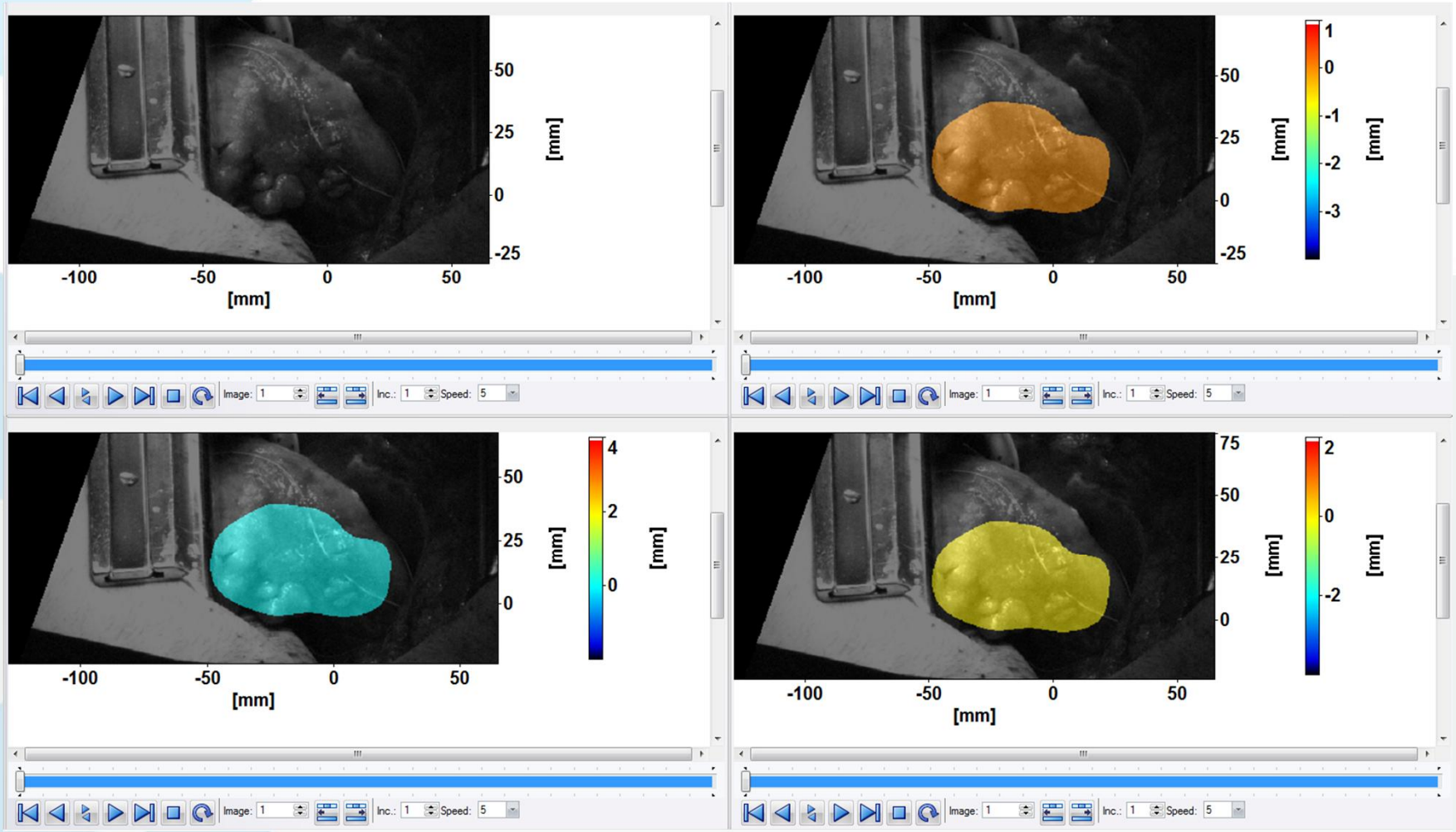


Stereo reconstruction error

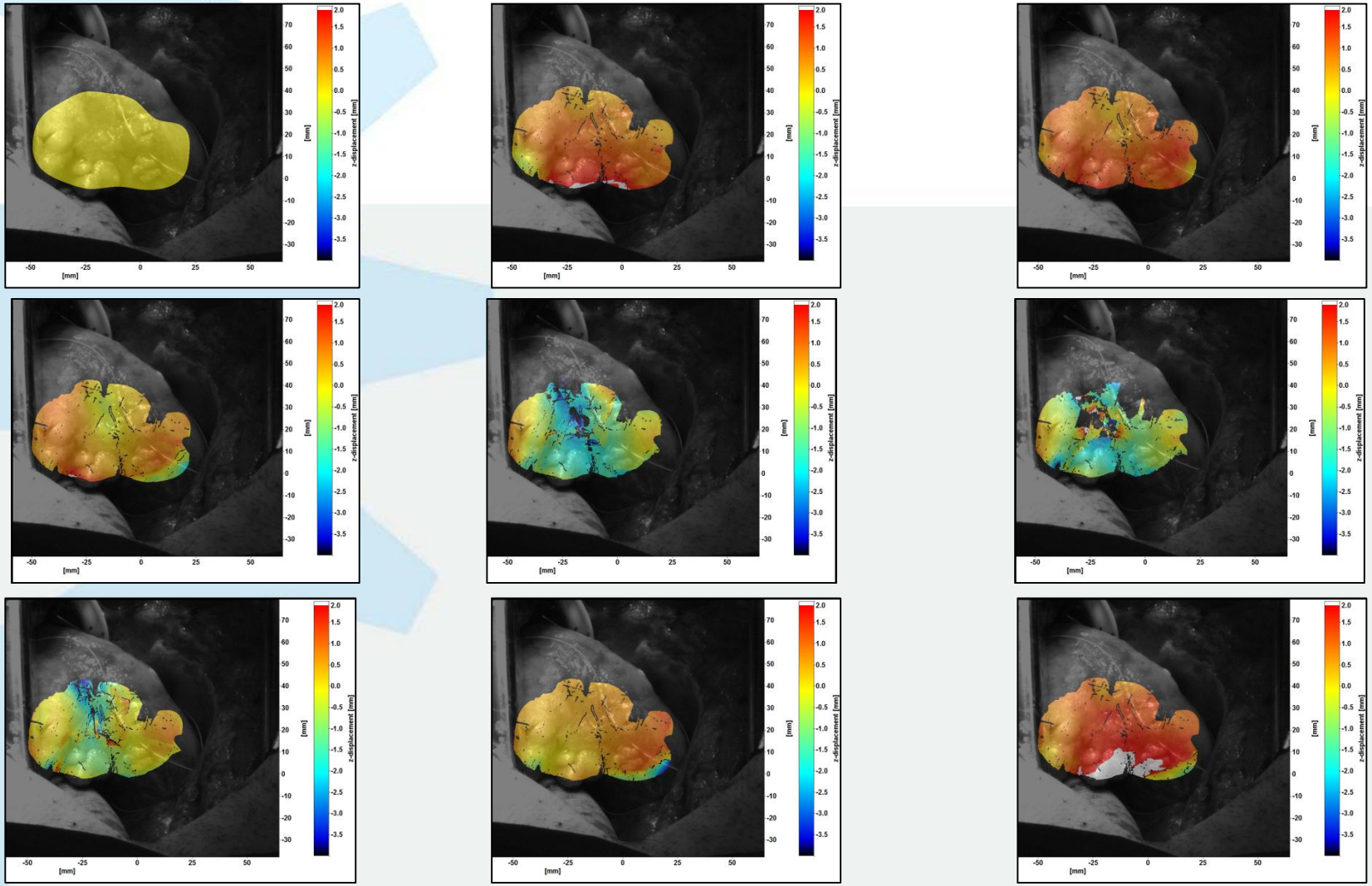




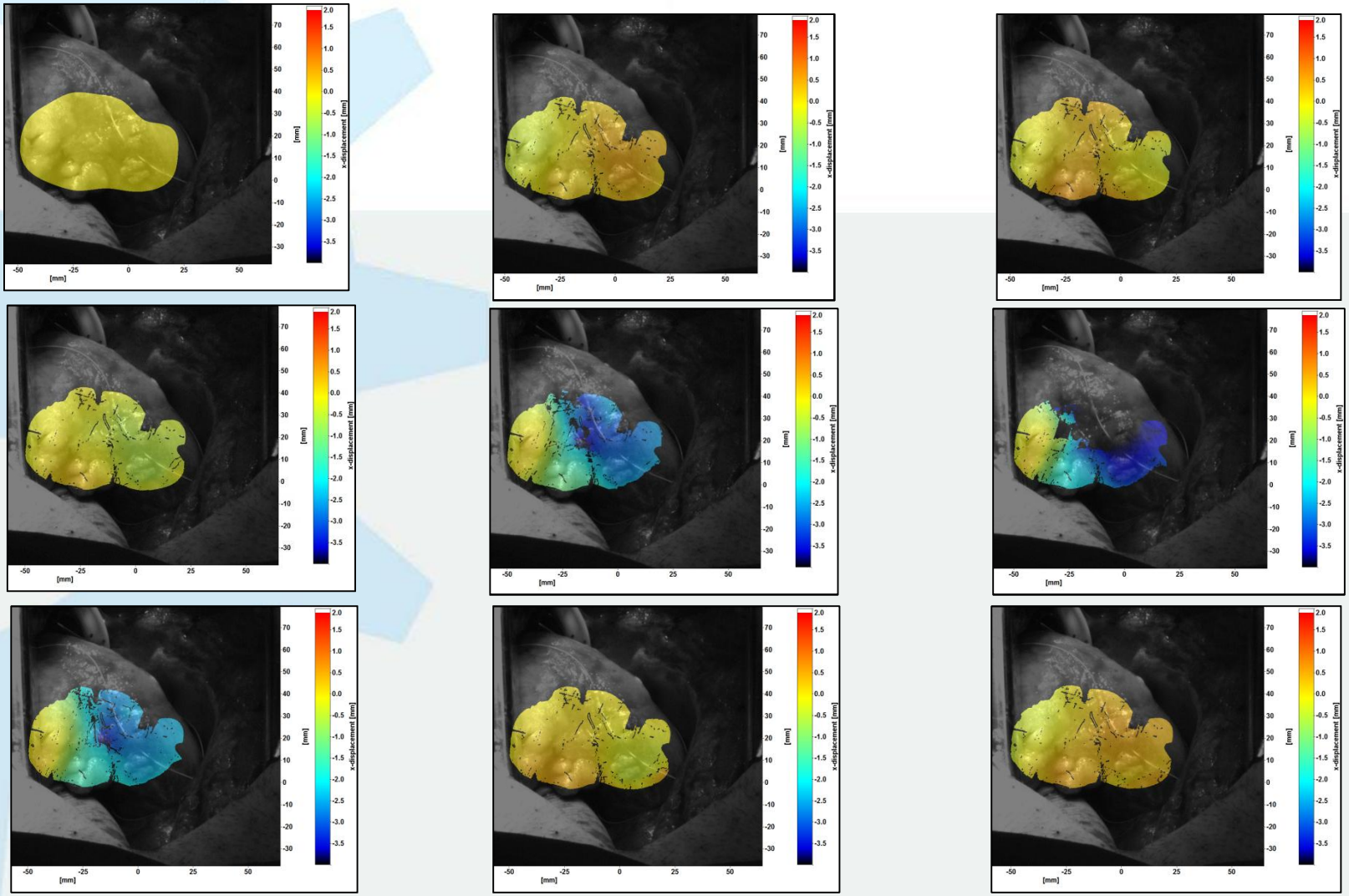
Preliminary Results



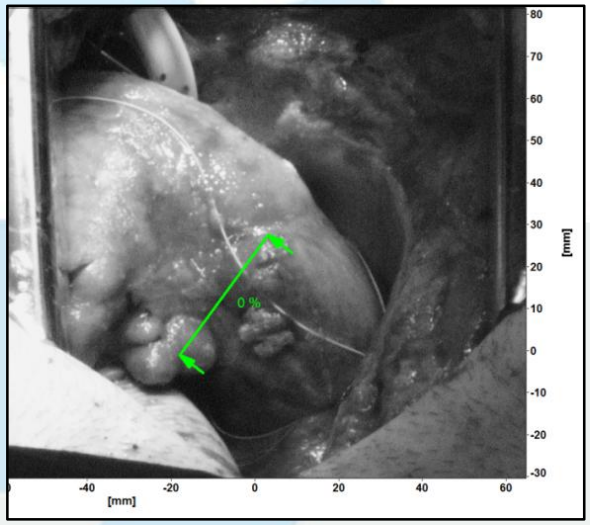
Displacement in the Z-direction

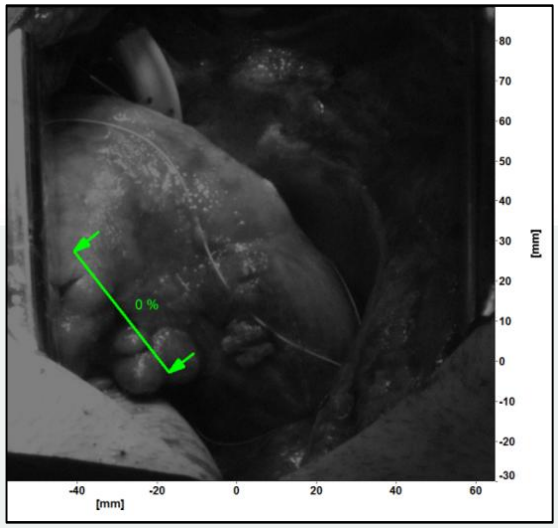


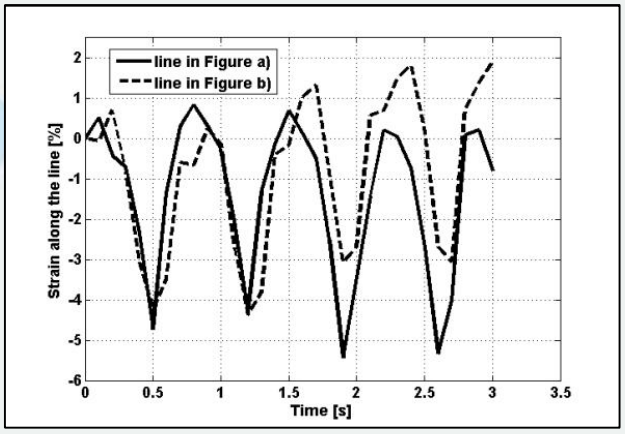
Displacement in the X-direction



Circumferential and longitudinal deformation







Conclusions

- Digital Image Correlation was used to analyse the deformation of the human heart
- The natural pattern of the heart is sufficient for DIC, but substantially better results could be obtained with artificial pattern
- The deformation in the Y-direction (vertical) was more homogeneous than the deformation in X and Z directions.
- Virtual extensometer can be used to obtain the deformations in circumferential and longitudinal directions
- More systematic work is needed

Thank you for your attention

Hokka et al. ”*In-Vivo deformation measurements of the human heart by 3D digital image correlation*”. J. Biomec. in press , available online.
Hokka el al.: “*DIC Measurements of the Human Heart during Cardiopulmonary Bypass Surgery”* In the proceedings of the Society for Experimental Mechanics Annual Congress 2015, Costa Mesa CA, USA.
Vogt et al. ”*A method for stereoscopic strain analysis of the right ventricle by digital image correlation during coronary bypass surgery*.” Biomed. Tech. In Press, available online.