Structured Decision Forests For Multi-modal Ultrasound Image Registration

Ozan Oktay[1], Andreas Schuh[1], Martin Rajchl[1], Kevin Keraudren[1],
Alberto Gomez[3], Mattias P. Heinrich[2], Graeme Penney[3], Daniel Rueckert[1]

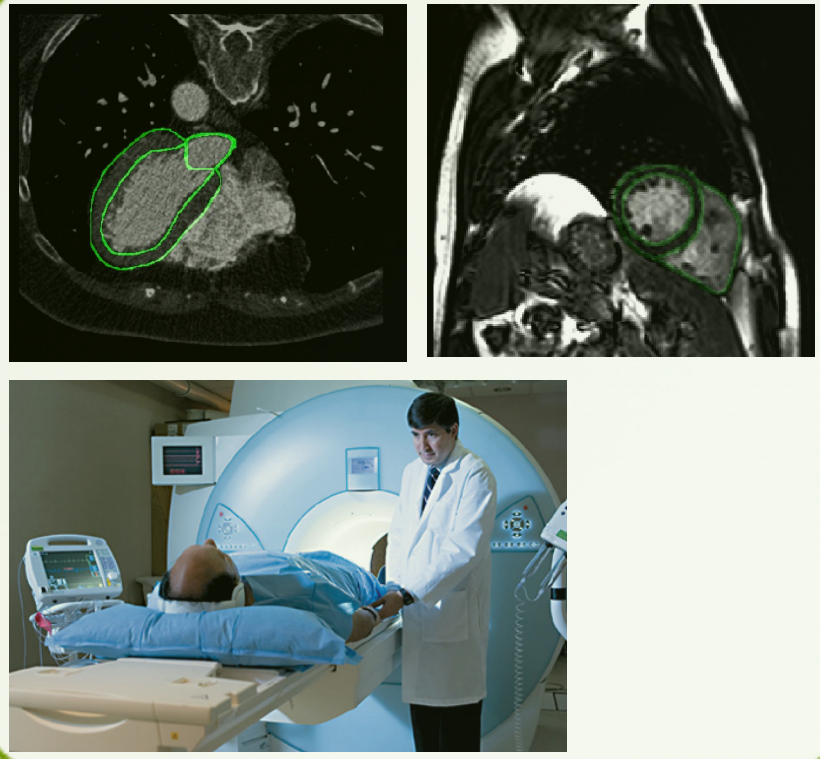
[1] Department of Computing, Imperial College London, UK
[2] Institute of Medical Informatics, University of Lübeck, Germany
[3] Division of Imaging Sciences and Biomedical Engineering, King's College London, UK

18th International Conference on Medical Image Computing
and Computer Assisted Interventions (MICCAI 2015)

BioMedIA
Imperial College London

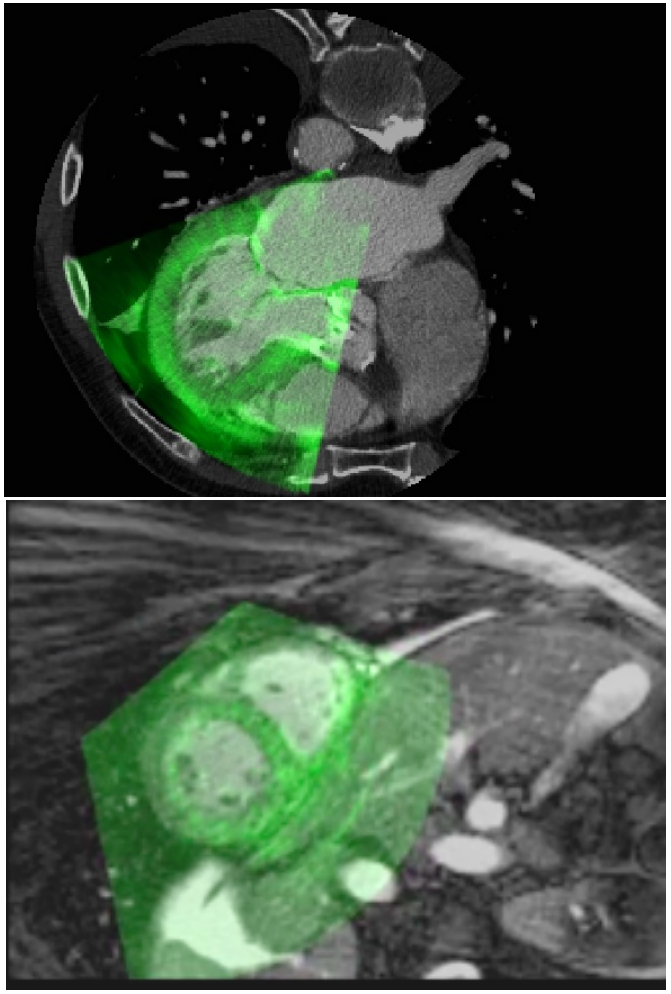
KING'S College LONDON
Imperial College London

Image Guided Cardiac Interventions



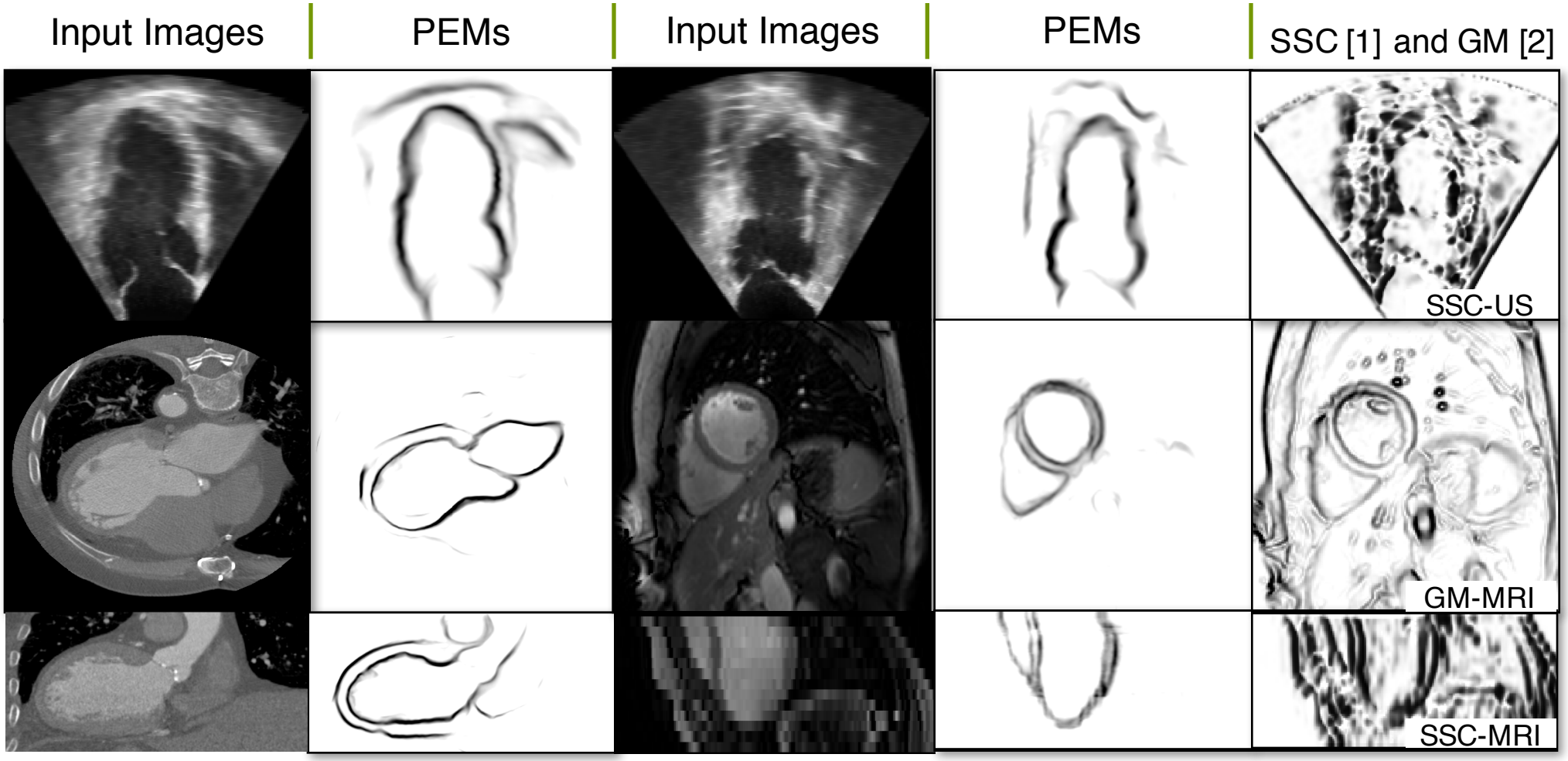
Pre-Operative Stage CT and MR Image Acquisitions

Spatial Alignment of Intra-Operative Images (for Better Image Guidance)



Spatial Alignment of Pre- and Intra-Operative Images

Probabilistic Edge Maps (PEMs)



GM: Intensity Gradient Magnitude – SSC: Self-Similarity Context Descriptor

1. Heinrich et al.: "Towards real-time multimodal fusion for image guided interventions using self-similarities." MICCAI'13
2. Wein et al.: "Global registration of US to MRI using the LC2 metric for enabling neurosurgical guidance." MICCAI'13

Advantages of Probabilistic Edge Maps

A. Modality independent (e.g. CT, MRI, US)

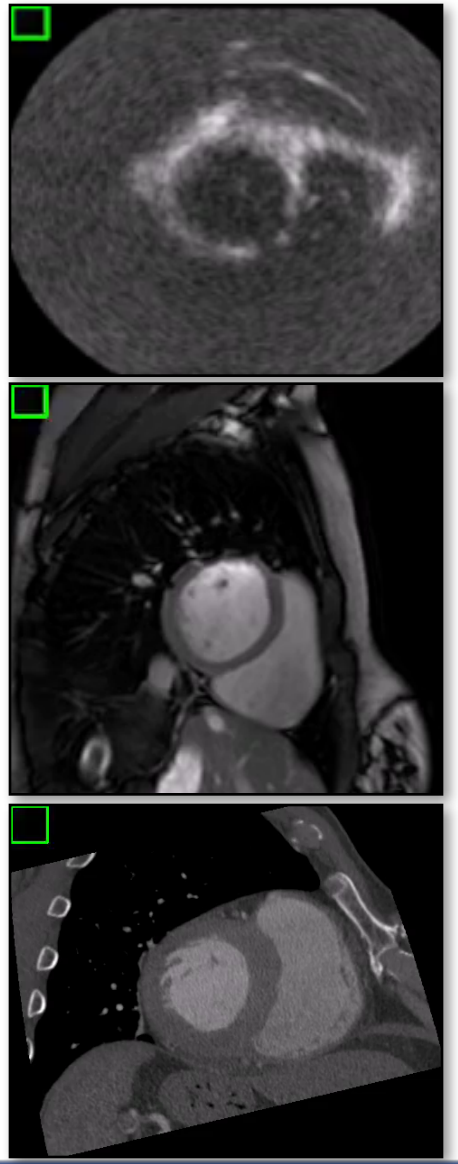
A. Computationally efficient (20s per image)

A. Target organ specific image registration

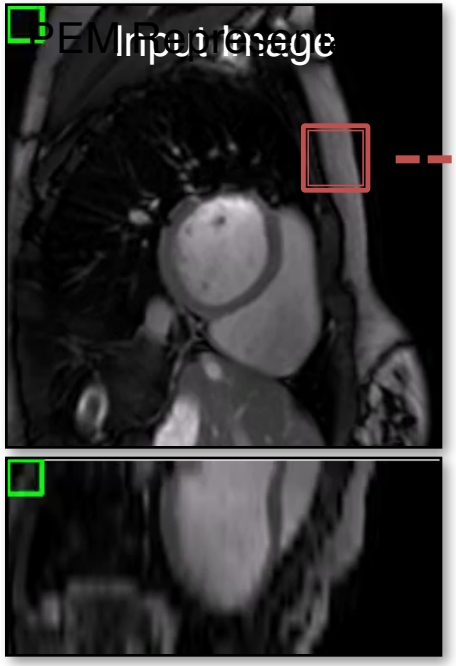
B. Accurate and smooth anatomical representation

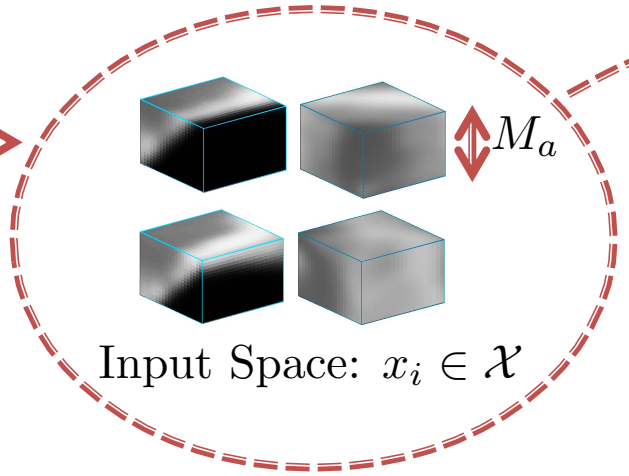
A. Same training and testing configuration is applied to all three modalities.

B. It does not require image segmentation.

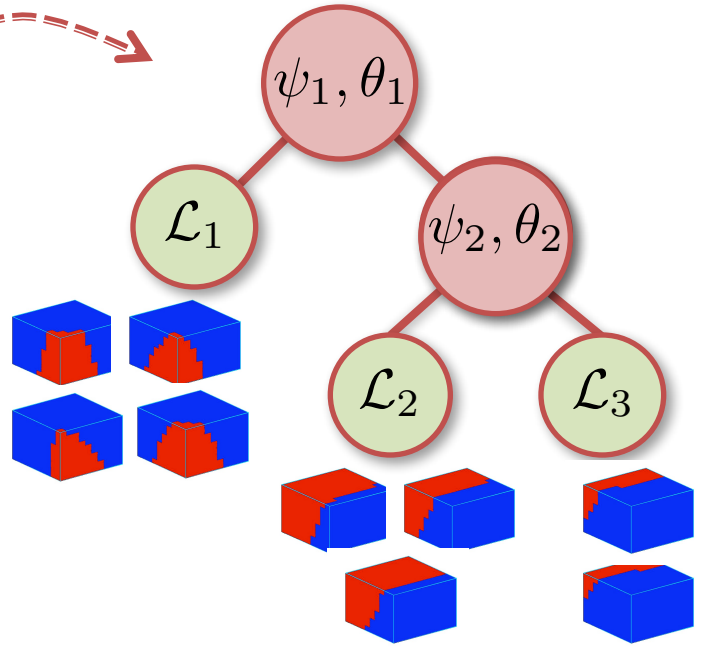


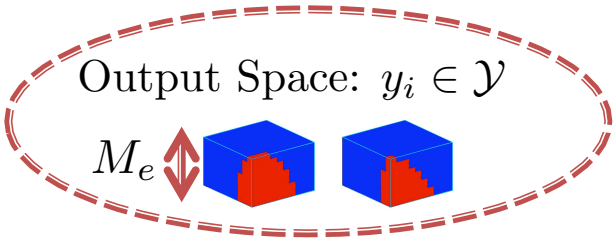
Structured Decision Forest (SDF)





Structured Decision Tree



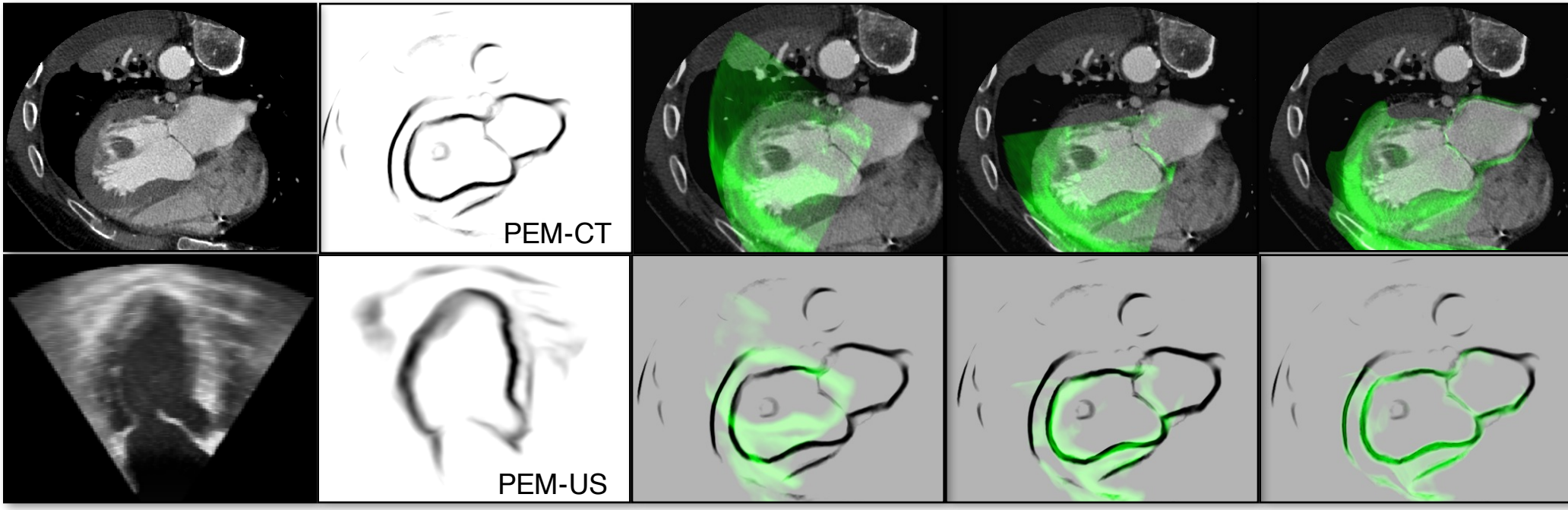


- Each voxel is voted for N_t x $(M_e)^3$
- N_t is the number of trees.
- All the votes are aggregated by averaging.

3. Dollar et al.: "Structured forests for fast edge detection." ICCV 2013
4. Kontschieder et al.: "Structured class-labels in random forests for semantic image labeling." ICCV 2011

The Proposed Multi-Modal Registration Framework

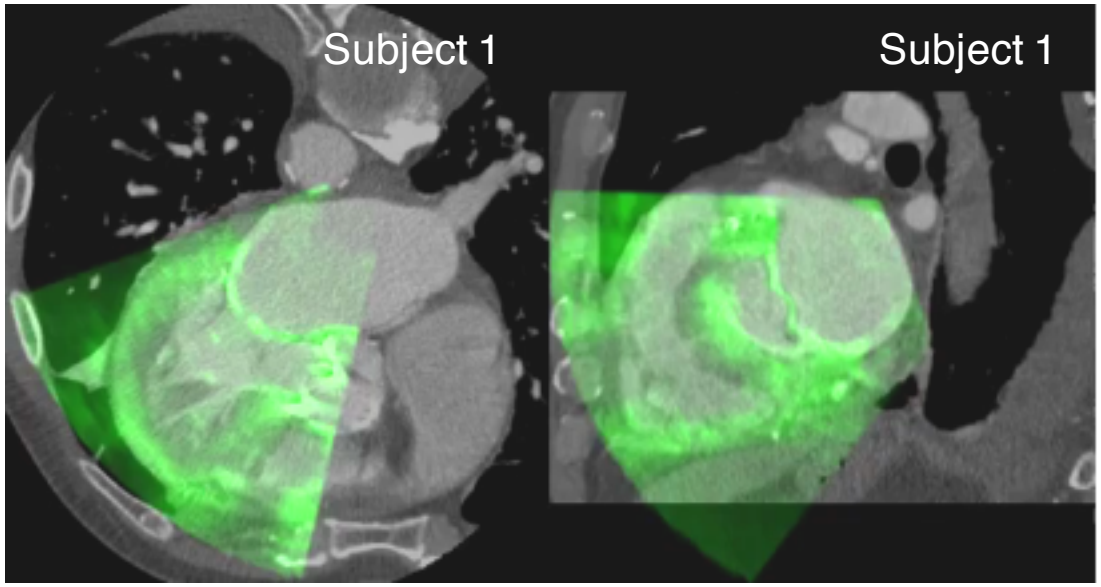
Input cardiac images	PEM representation	Initial Alignment of the images	Global alignment with robust block matching [2]	B-spline FFD based non-rigid registration [1]

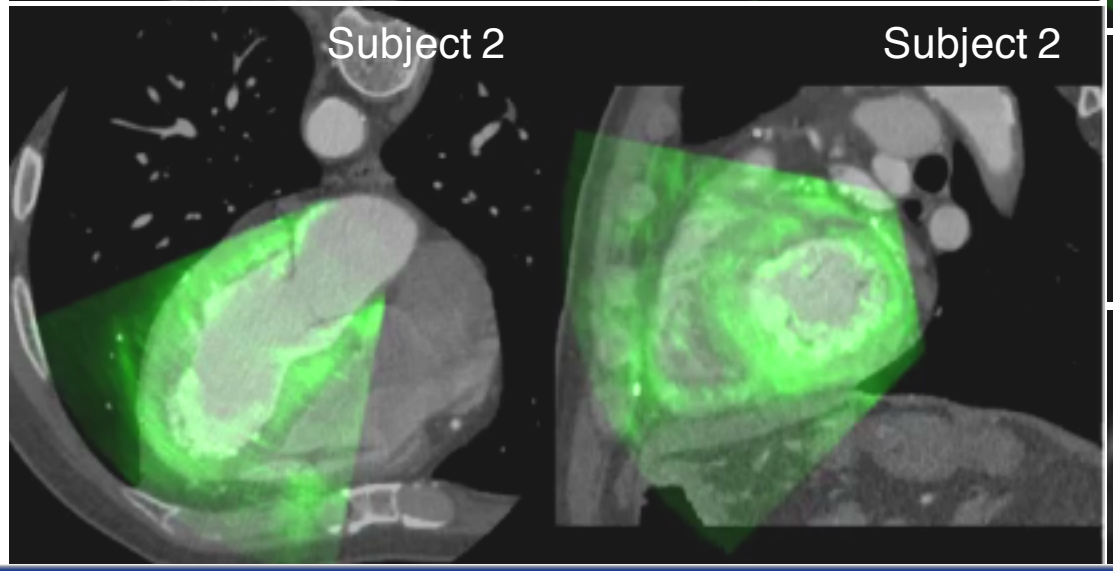


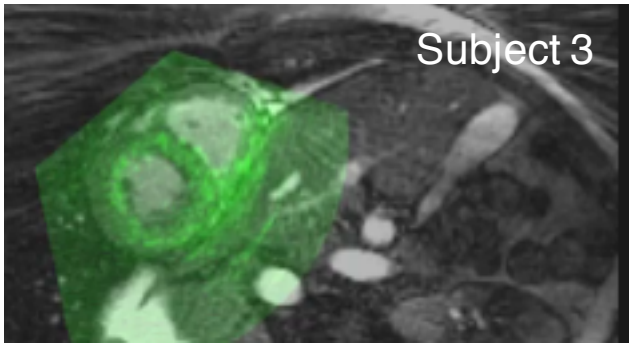
Computation Time (Quad-core 3.0GHz)	~20s per image	~21s per image	~73s per image

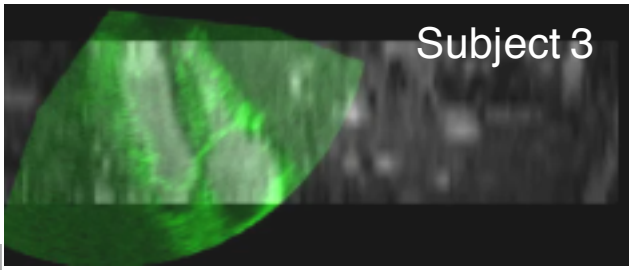
5. Rueckert et al.: “Non-rigid registration using free-form deformations: Application to breast MR images.” TMI’99
6. Ourselin et al.: “Reconstructing a 3D structure from serial histological sections.” Image and Vision Computing ’01

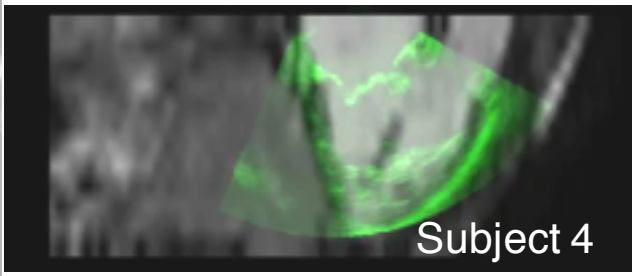
US/CT and US/MR Image Alignment Results

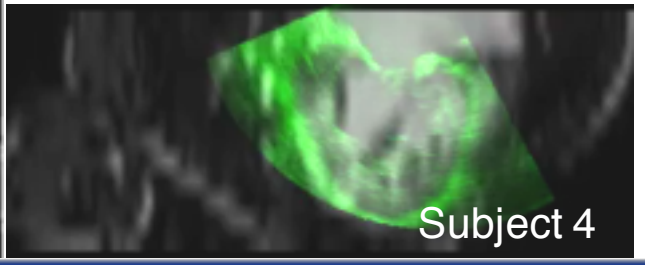




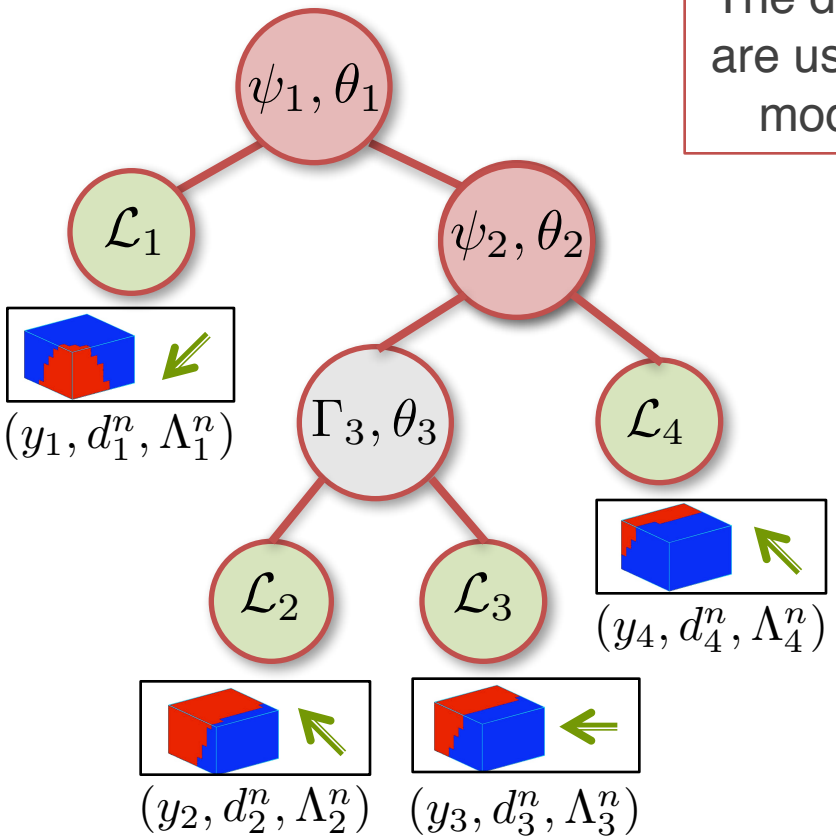








Structured Regression Forest (SRF)

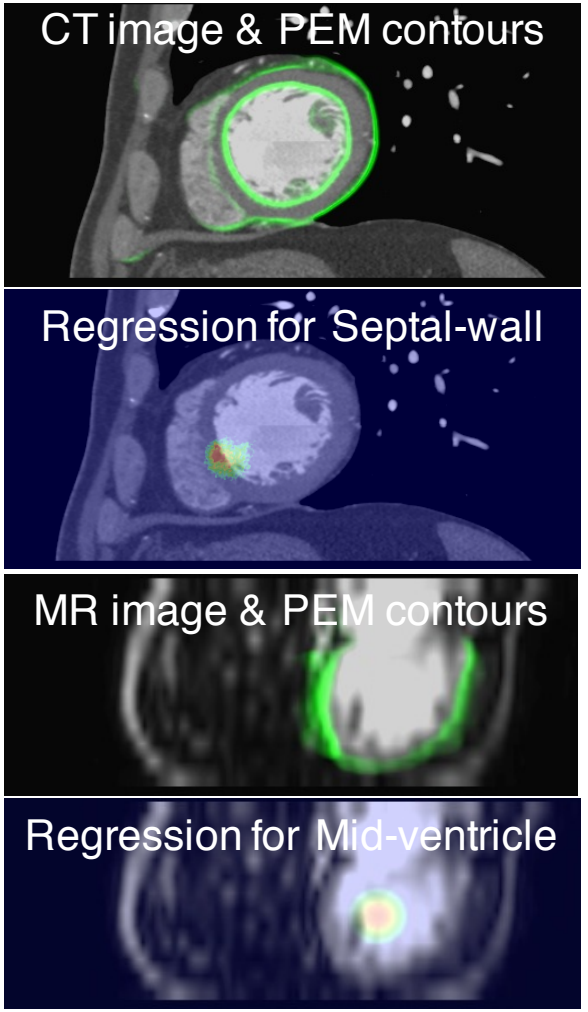


The detected landmark points are used to initialize the multi-modal image registration.

: Leaf Node

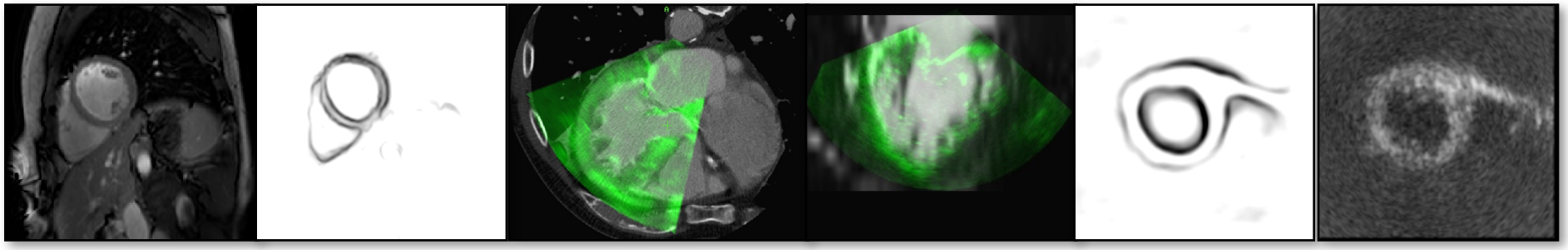
: Classification Node

: Regression Node



7. Gall J., et al. ”Class-Specific Hough Forests for Object Detection.” CVPR 2009.
8. Criminisi A., et al. “Regression Forests for Efficient Anatomy Detection and Localization in CT Studies.” MCV 2010.

Structured Decision Forests For Multi-modal Ultrasound Image Registration



- Acknowledgements:

Imperial College London

KING'S College LONDON

EPSRC
Engineering and Physical Sciences Research Council

- Source code will be available at http://www.doc.ic.ac.uk/~oo2113/