Non-rigid Registration of 3D Ultrasound Images Using Model-based Segmentation

CVPR Workshop on Registration of Very Large Images

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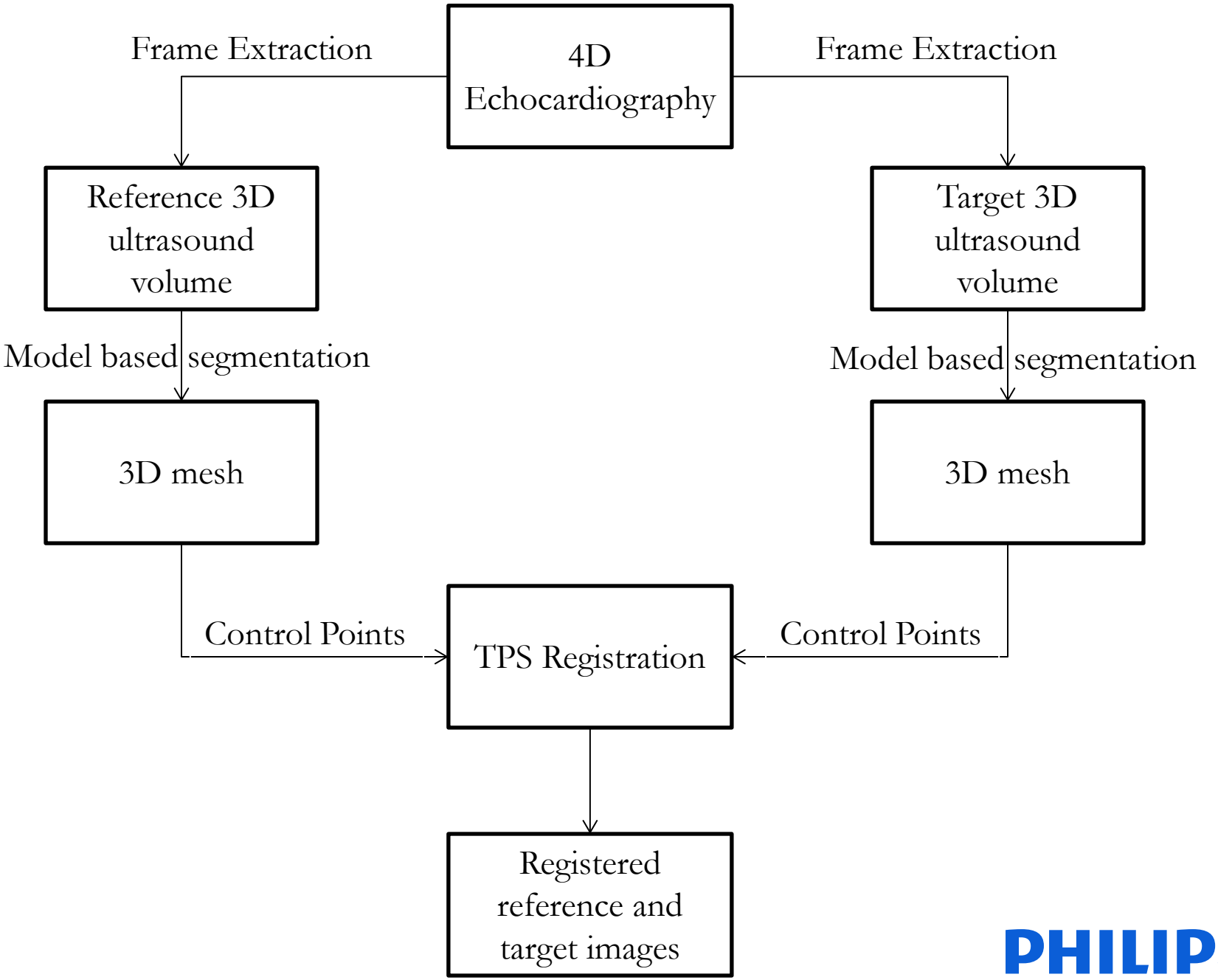
Motivation

- Non-rigid registration computational performance depends on the image size
- Voxel-based approaches are computationally intensive, exponentially proportional to image resolution
- An approach that is *independent of the image size*
- Registration computation speed remains constant with increasing image resolution

Method

- Model based segmentation:
  - Fully automated, rapid and highly accurate segmentation on 3D volumes
  - Fixed mesh topology for point correspondence between segmented volumes
- Thin plate spline (TPS) registration
  - TPS applied to segmented meshes from 4D echocardiogram images


4D Echocardiography
Frame Extraction
Frame Extraction
Reference 3D ultrasound volume
Target 3D ultrasound volume
Model based segmentation
Model based segmentation
3D mesh
3D mesh
Control Points
Control Points
TPS Registration
Registered reference and target images

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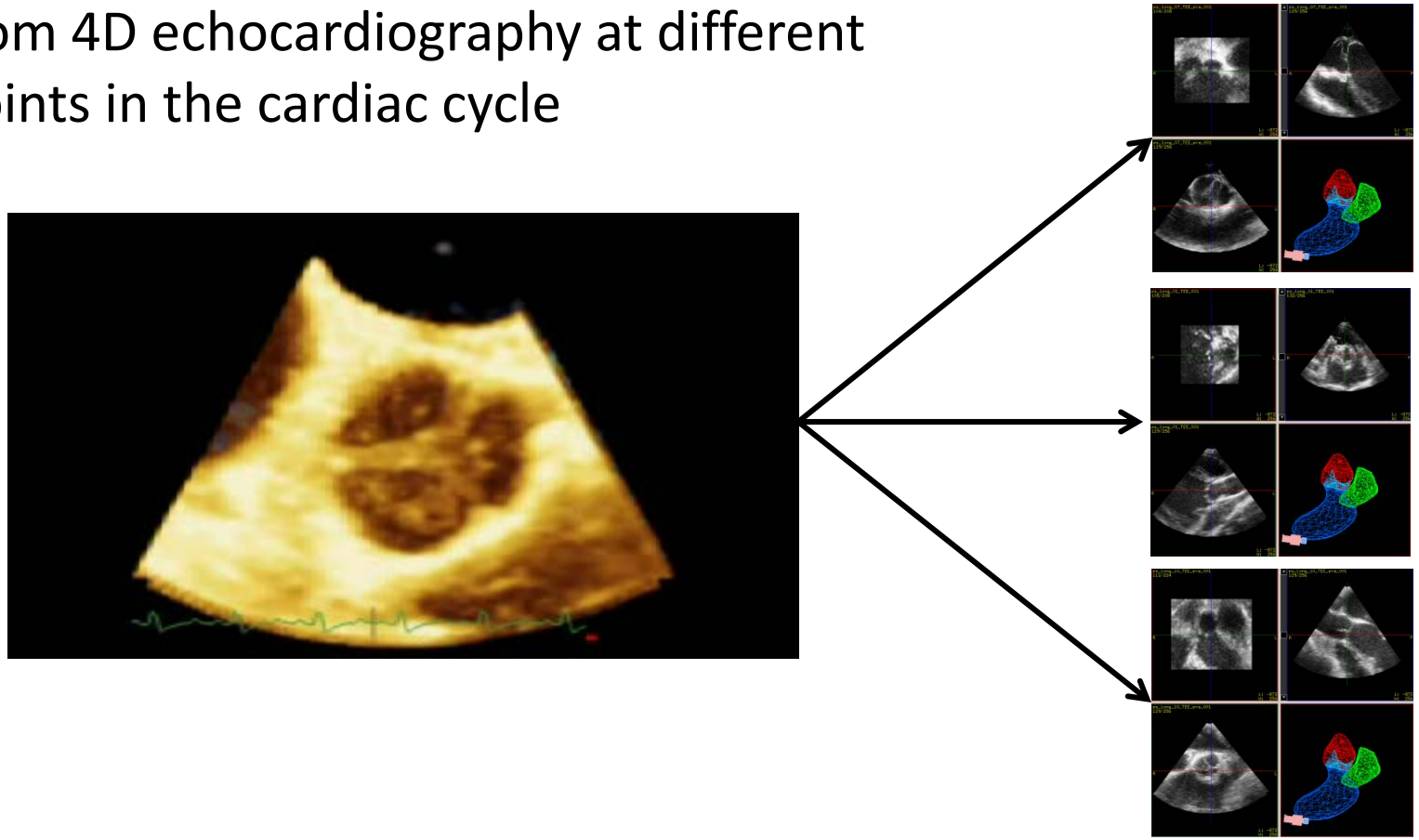
3D ultrasound volumes were extracted from 4D echocardiography at different points in the cardiac cycle



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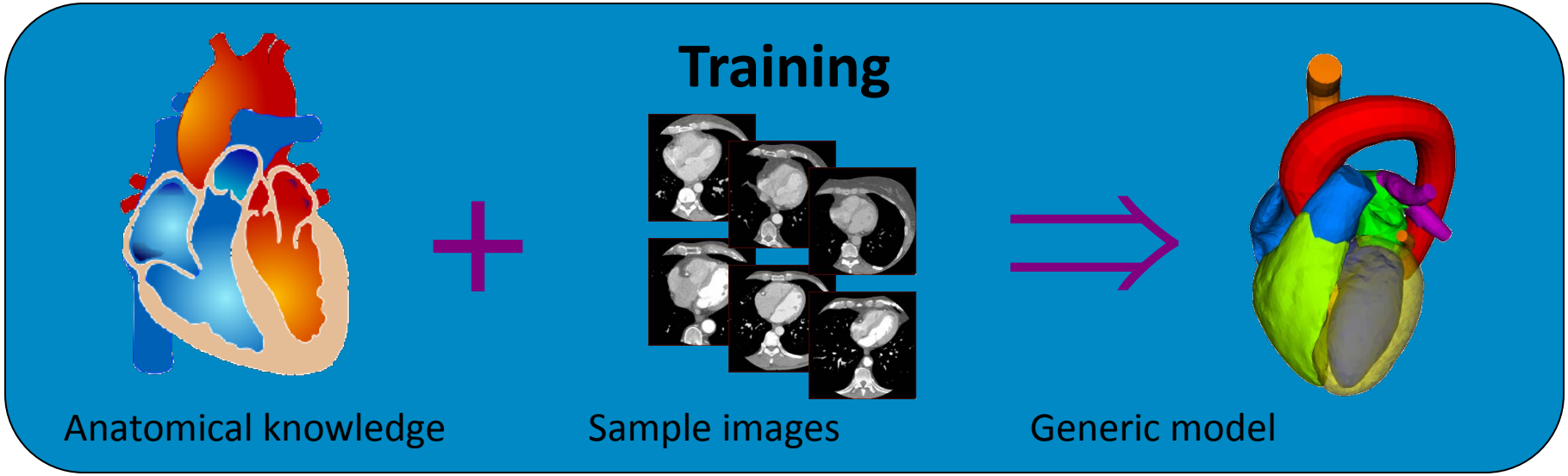
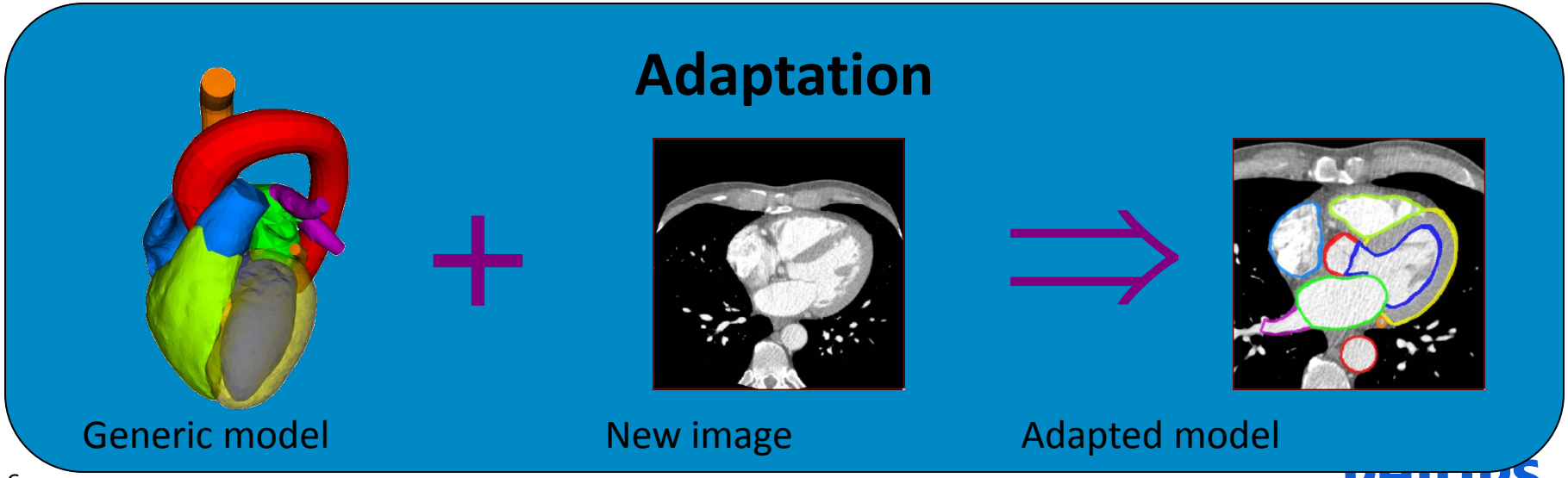
Shape-constrained Deformable Models





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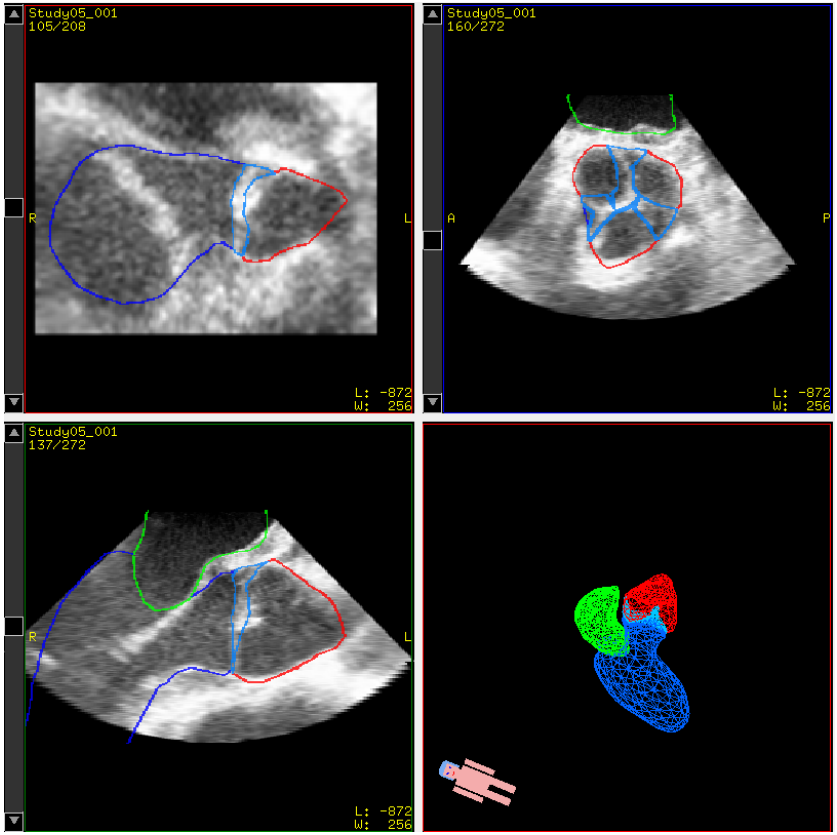
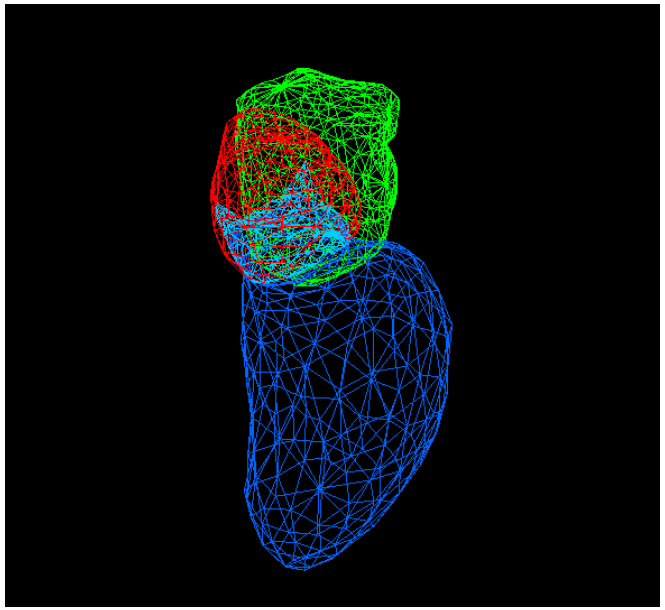
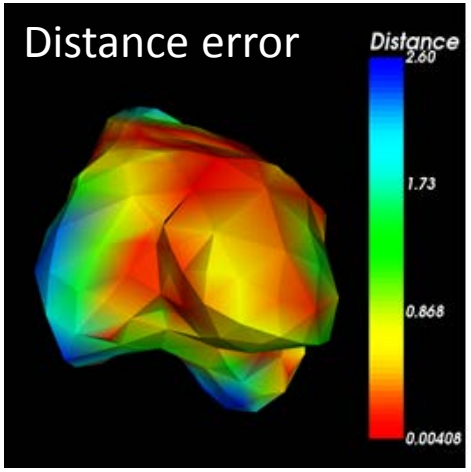
Segmentation of heart aortic root model







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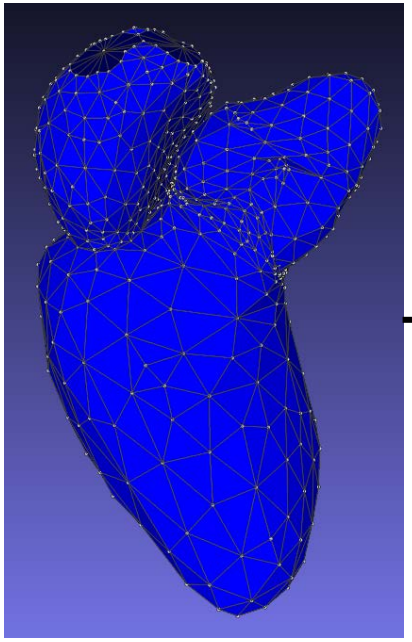
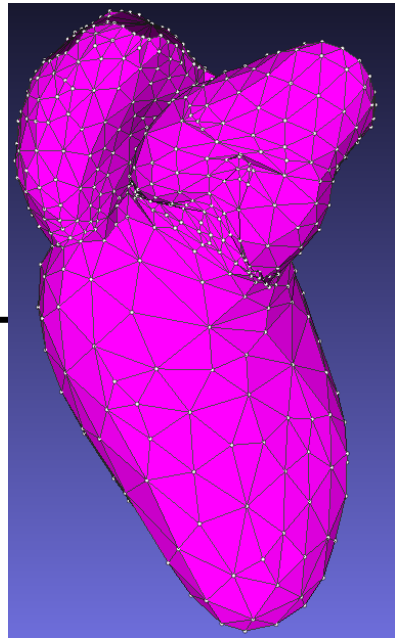
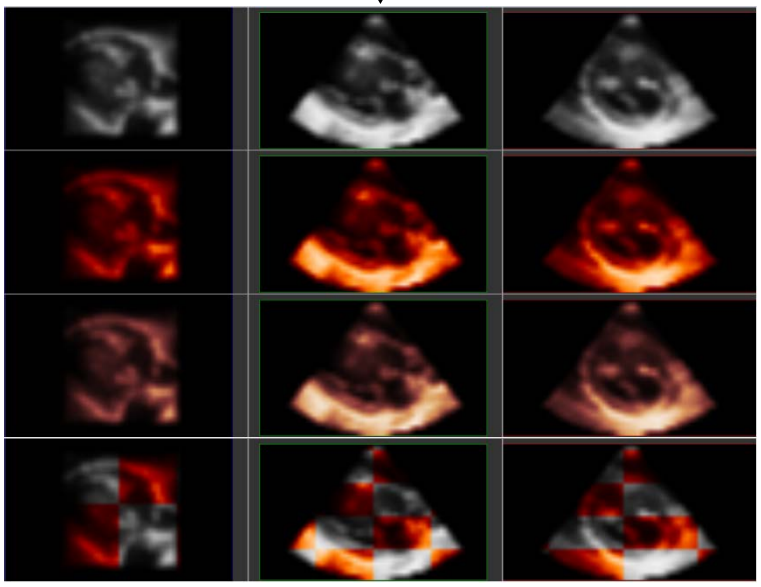


TPS registration
of control points





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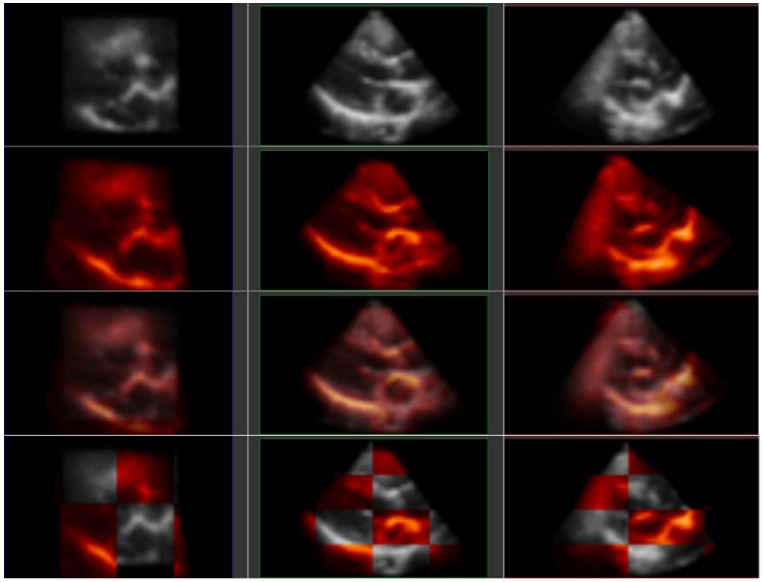
Results: Inter-Patient Registration

Not Registered



Registered

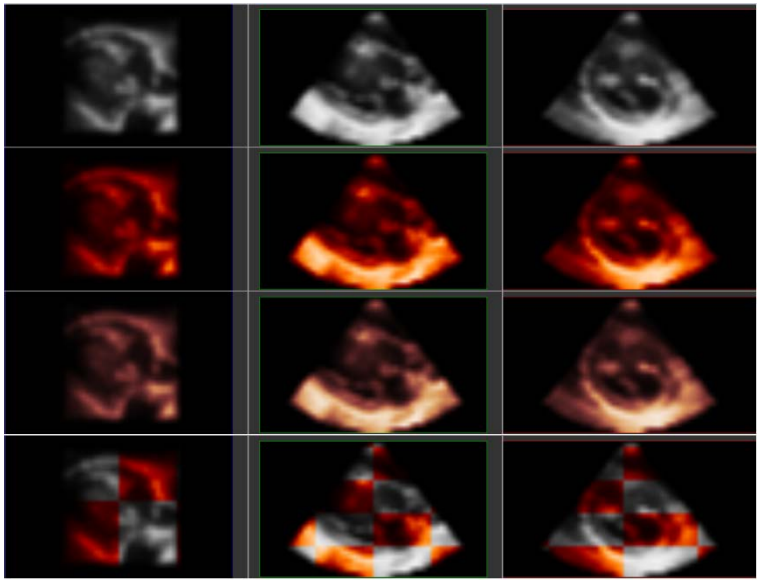


Image overlay of end of diastole to end of systole volumes in cardiac cycle

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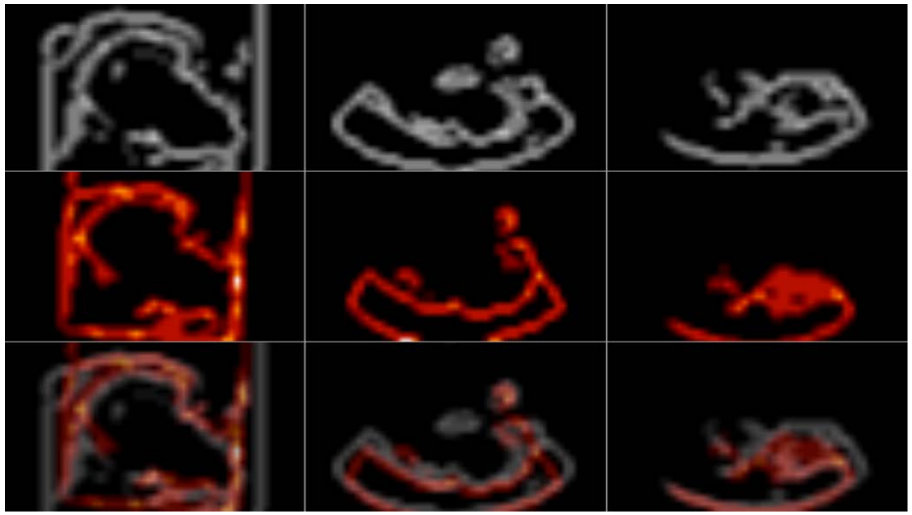
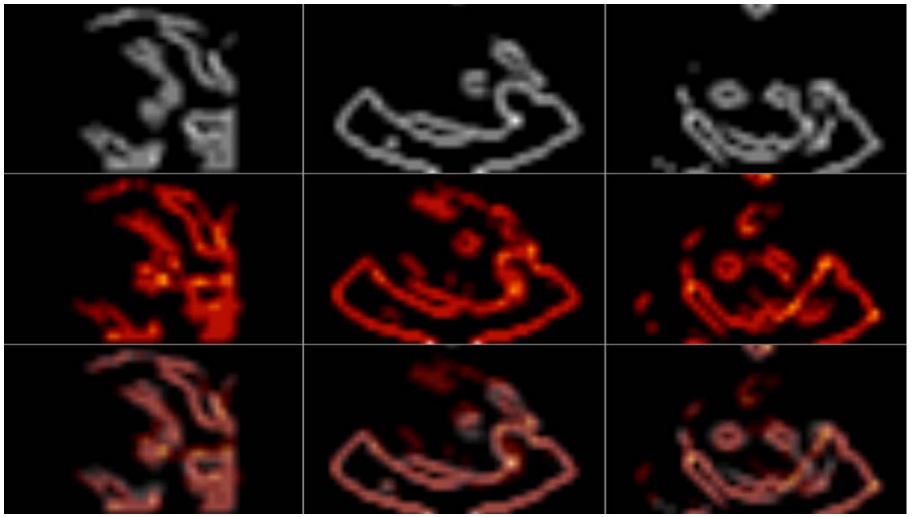
Results: Inter-Patient Registration

Not Registered



Registered



Overlay of image boundaries of end of diastole to end of systole volumes in cardiac cycle

Results: Intra-Patient Registration

Not Registered

Registered

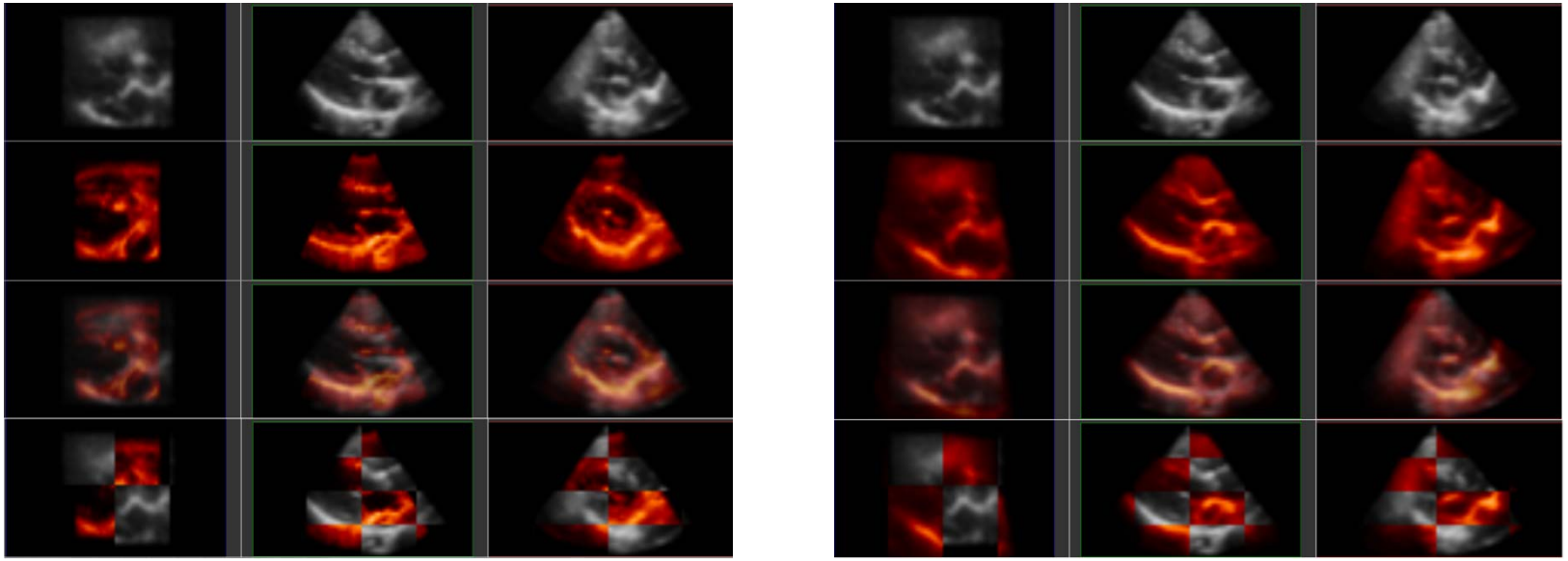


Image overlay of end of diastole volumes in different patients

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Conclusion

- Method for non-rigid registration of large 3D data volumes that does not depend on the image size and any intensity-based similarity metrics
- Rapid segmentation provides accurate point-based correspondence that can be used for TPS registration
- Registration computational performance remains constant with increasing image size and resolution


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