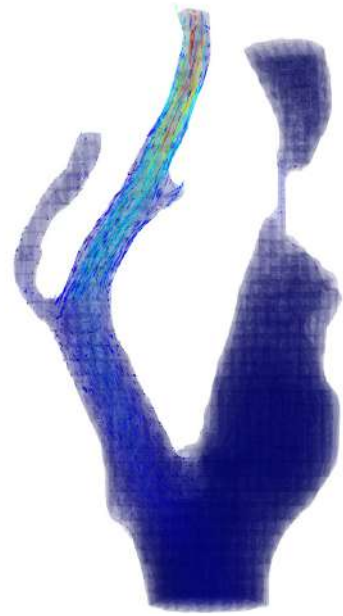
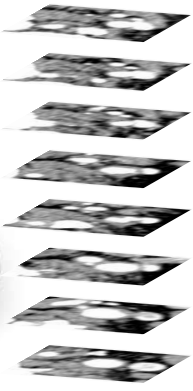
Scan-based immersed isogeometric analysis



Sai Chandana Divi
Eindhoven University of Technology
&
University of Pavia
18 March 2022

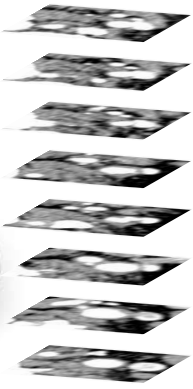
Scan-based simulations



Scan

[Image courtesy: Canon]

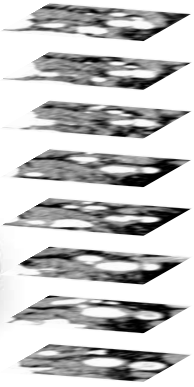
Scan-based simulations



Scan

[Image courtesy: Canon]

Scan-based simulations



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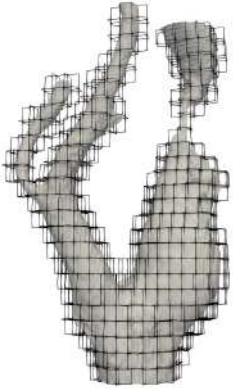
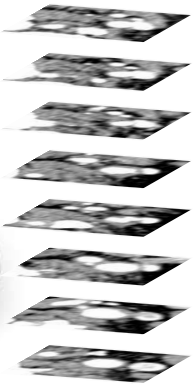


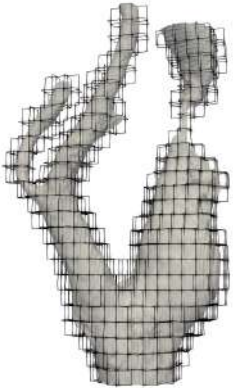
Mesh

[Image courtesy: Canon]

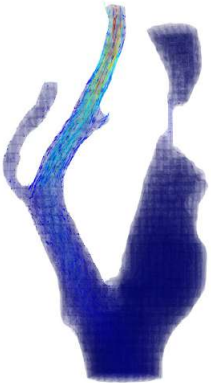
Scan-based simulations



Scan



Mesh



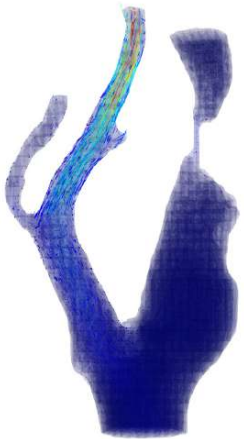
Simulation

[Image courtesy: Canon]

Current status of scan-based simulations

Advantages of current workflow

- Reconstruction of geometry with smooth boundaries
- Fewer degrees of freedom than voxel simulation
- Stabilized method for incompressible flow problems



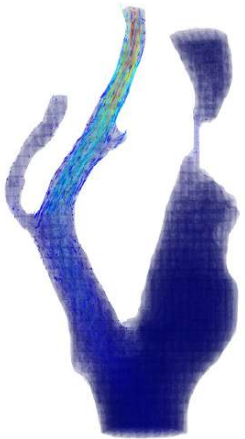
Current status of scan-based simulations

Advantages of current workflow

- ▲ Reconstruction of geometry with smooth boundaries
- ▲ Fewer degrees of freedom than voxel simulation
- ▲ Stabilized method for incompressible flow problems

Challenges for patient-specific analysis

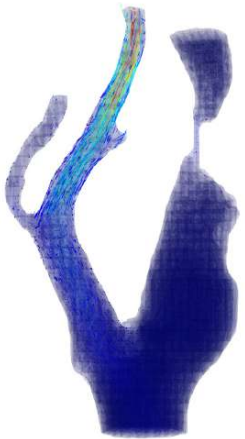
- ▼ High number of quadrature points
- ▼ Topological anomalies - features of voxel size
- ▼ Need for manual control of accuracy



Scan-based immersed isogeometric analysis

Objective

To enable an automatic scan-based workflow for immersed isogeometric analysis



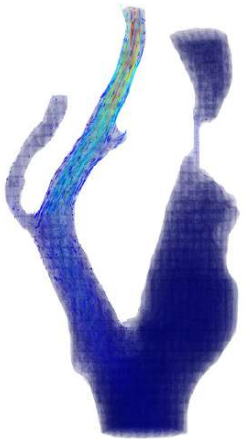
Scan-based immersed isogeometric analysis

Objective

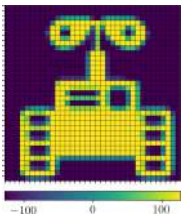
To enable an automatic scan-based workflow for immersed isogeometric analysis

Contributions

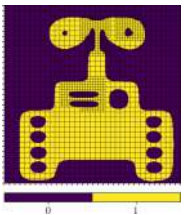
- Optimized quadrature scheme
- Restored topological anomalies
- Automated control of accuracy



Topology preservation

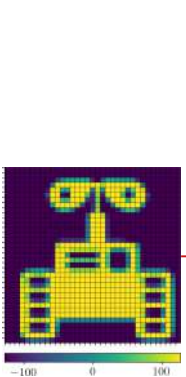


Scan data



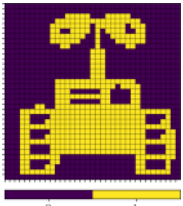
Smooth segmentation

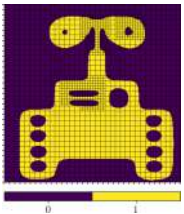
Topology preservation



Scan data

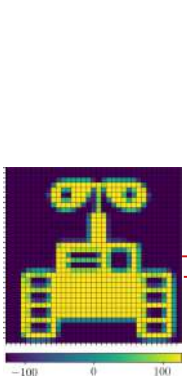
Segmentation





Smooth segmentation

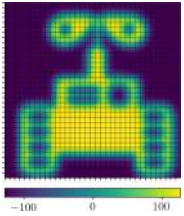
Topology preservation

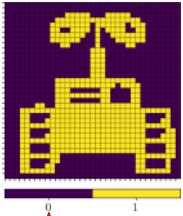


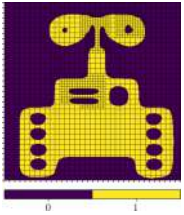
Scan data

Segmentation

Smoothing

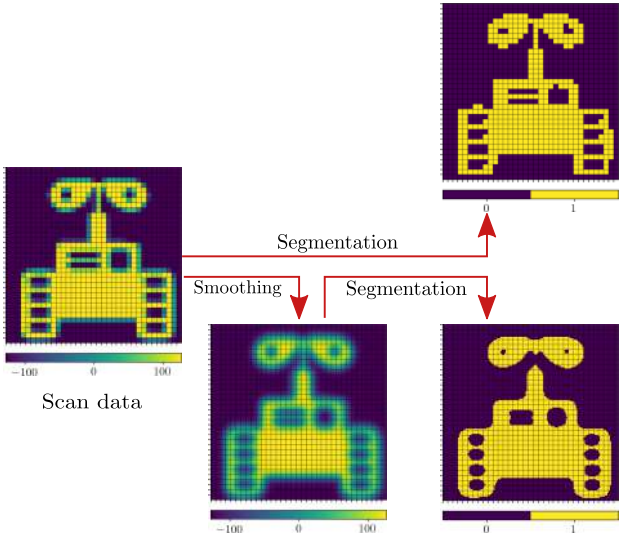




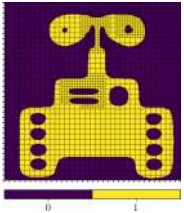


Smooth segmentation

Topology preservation

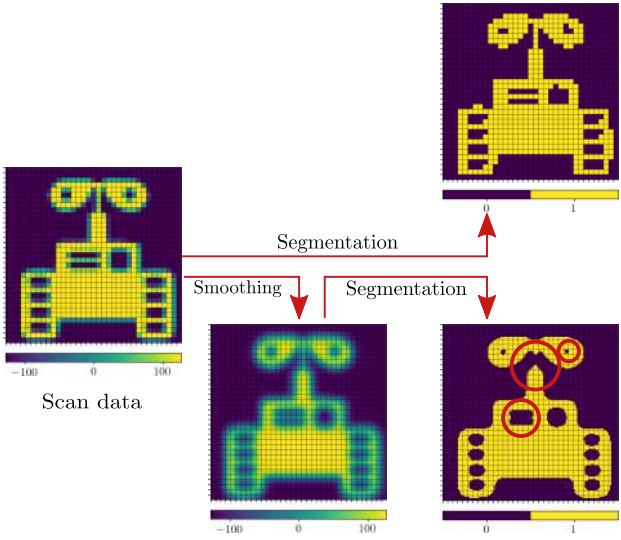


Scan data

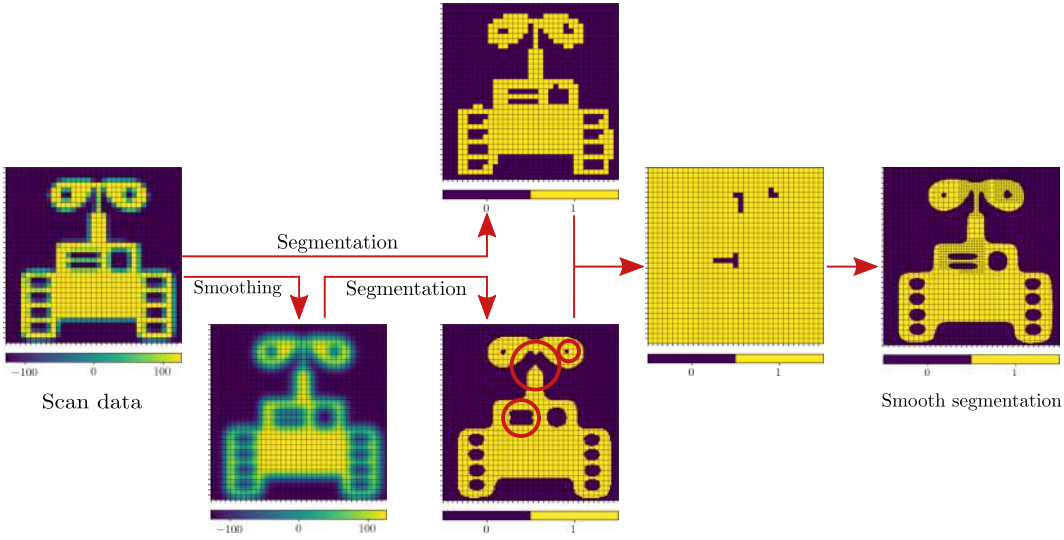


Smooth segmentation

Topology preservation



Topology preservation



Topology-preserving scan-based immersed isogeometric analysis

Before

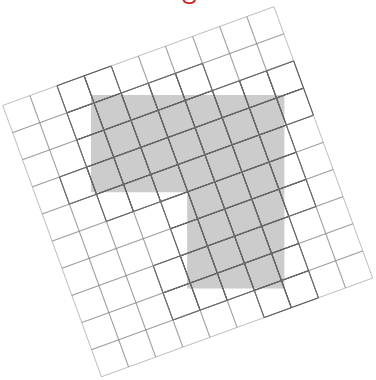
Topology-preserving scan-based immersed isogeometric analysis

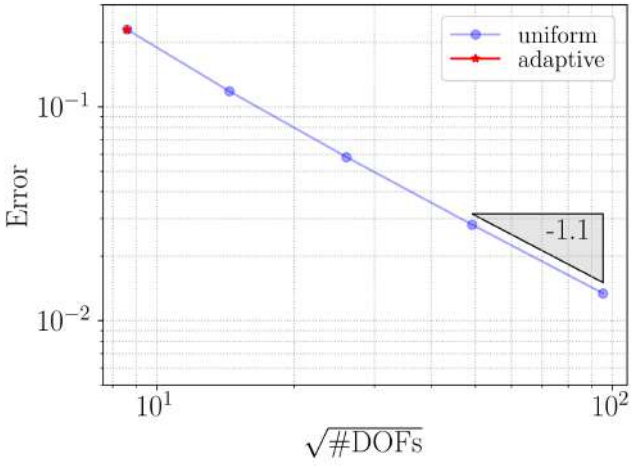
Before

After

Residual-based error estimation

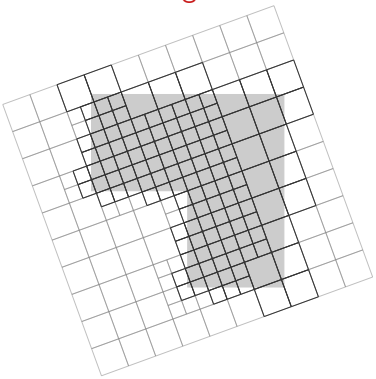
Stage 0

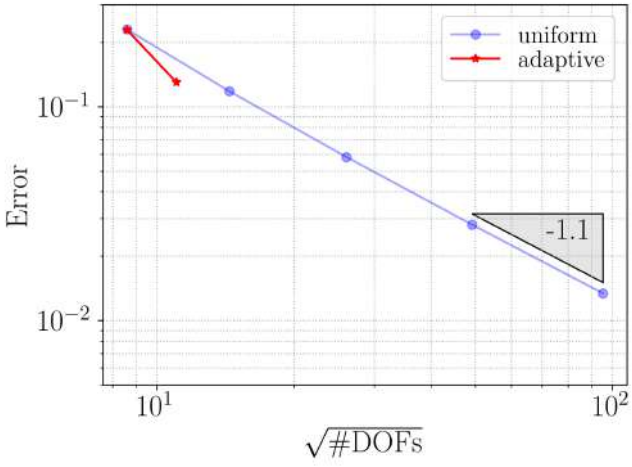




Residual-based error estimation

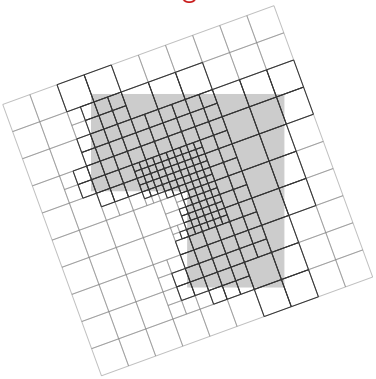
Stage 1

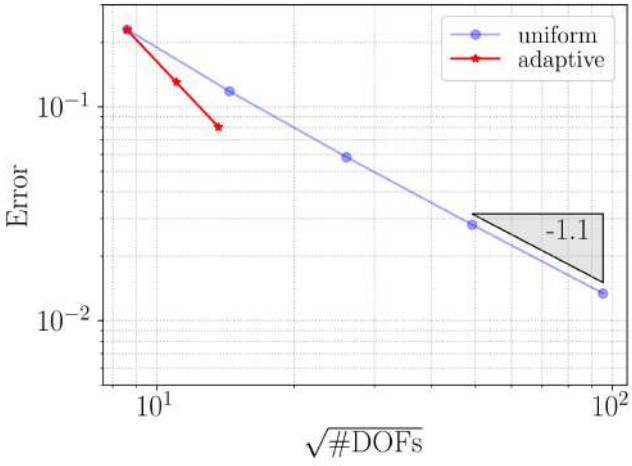




Residual-based error estimation

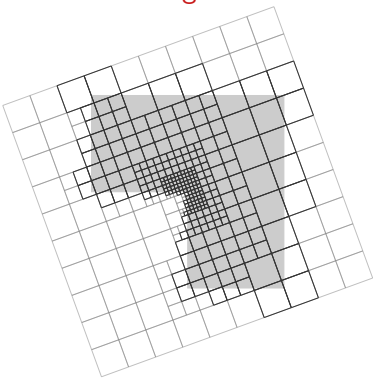
Stage 2

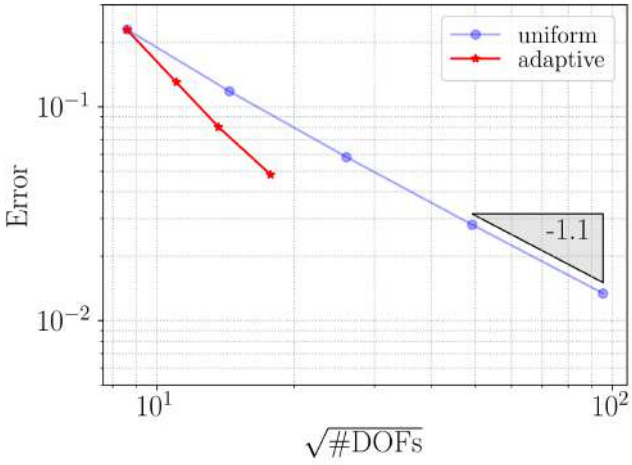




Residual-based error estimation

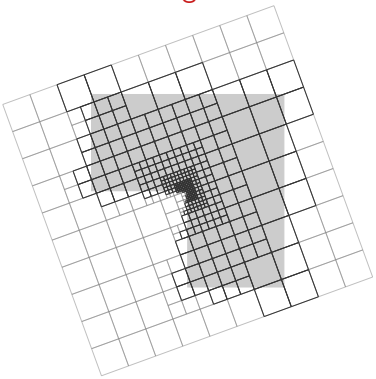
Stage 3

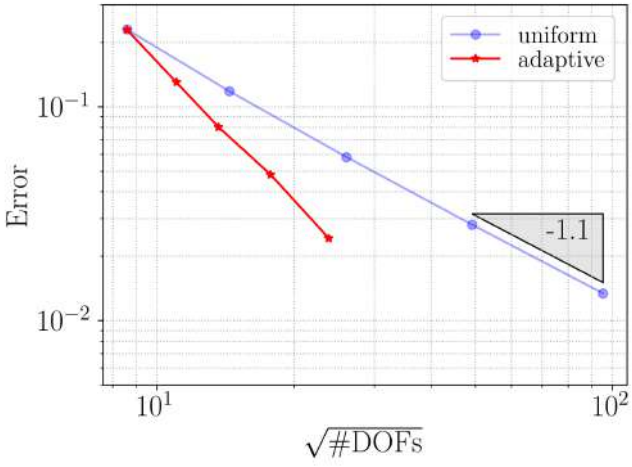




Residual-based error estimation

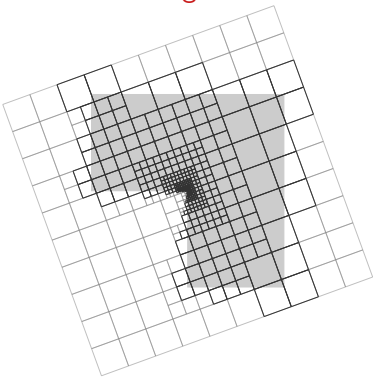
Stage 4

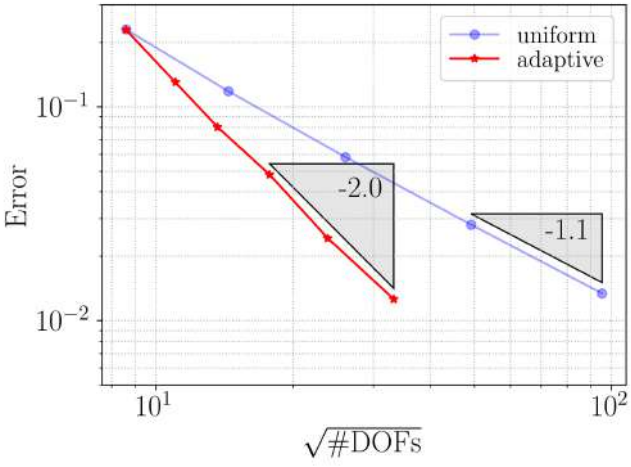




Residual-based error estimation

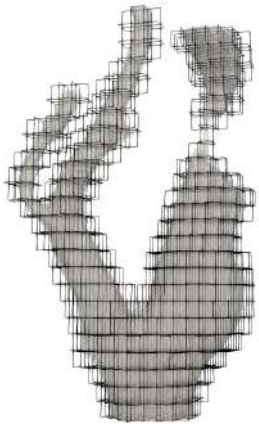
Stage 5





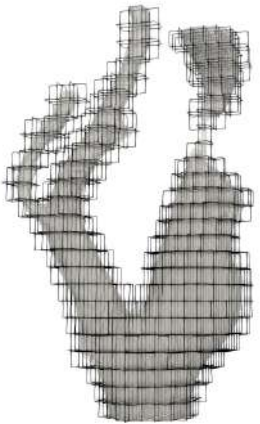
Patient-specific scan-based immersed isogeometric analysis

Initial mesh

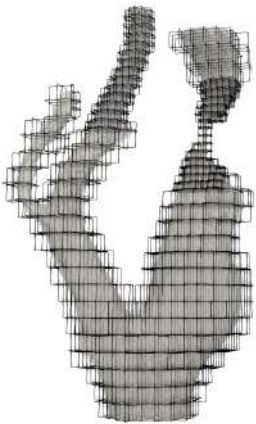


Patient-specific scan-based immersed isogeometric analysis

Initial mesh

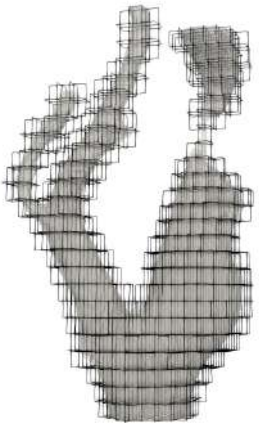


Stage 1

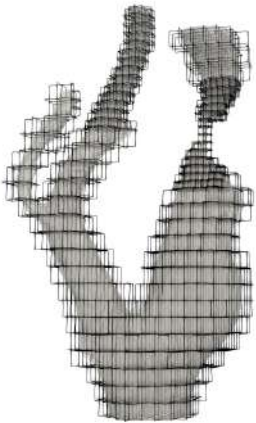


Patient-specific scan-based immersed isogeometric analysis

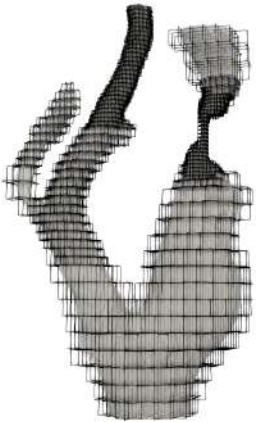
Initial mesh



Stage 1



Stage 2



Scan-based immersed isogeometric analysis

Conclusions

- Adaptive scheme to optimize quadrature points
- Algorithm to preserve topology
- Refinement technique to automate accuracy control