3D guidance based on tracking systems and preoperative data for endovascular procedures

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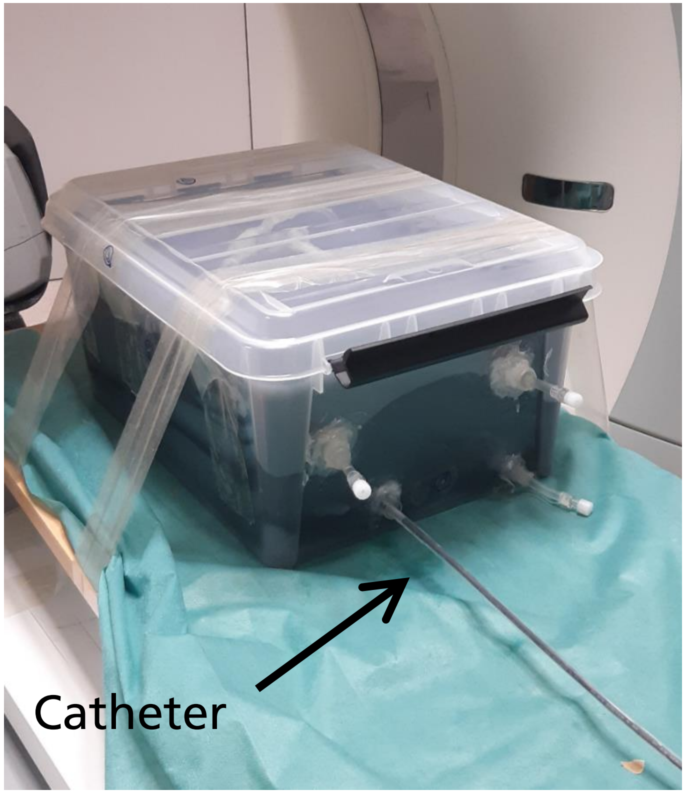
Motivation – What is guidance?

View in real world



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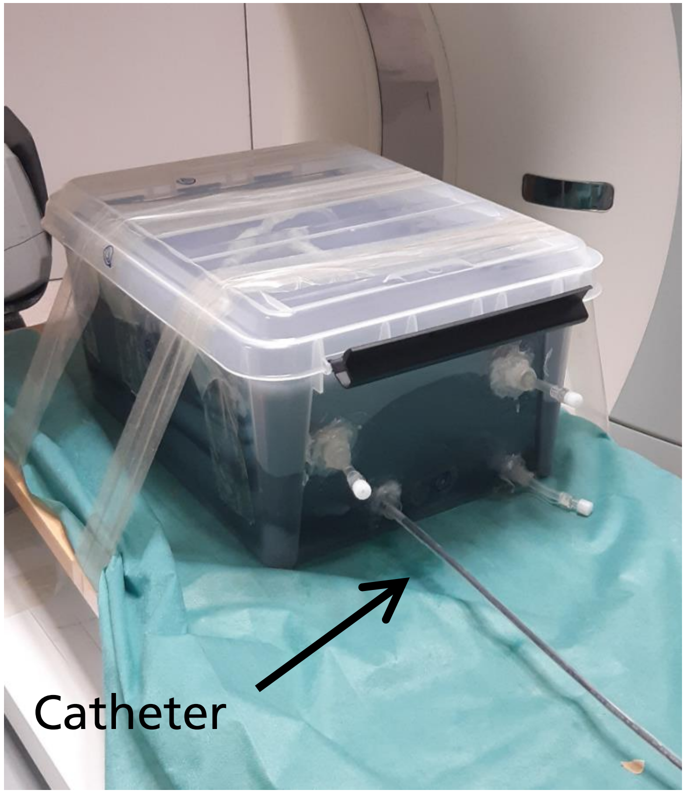
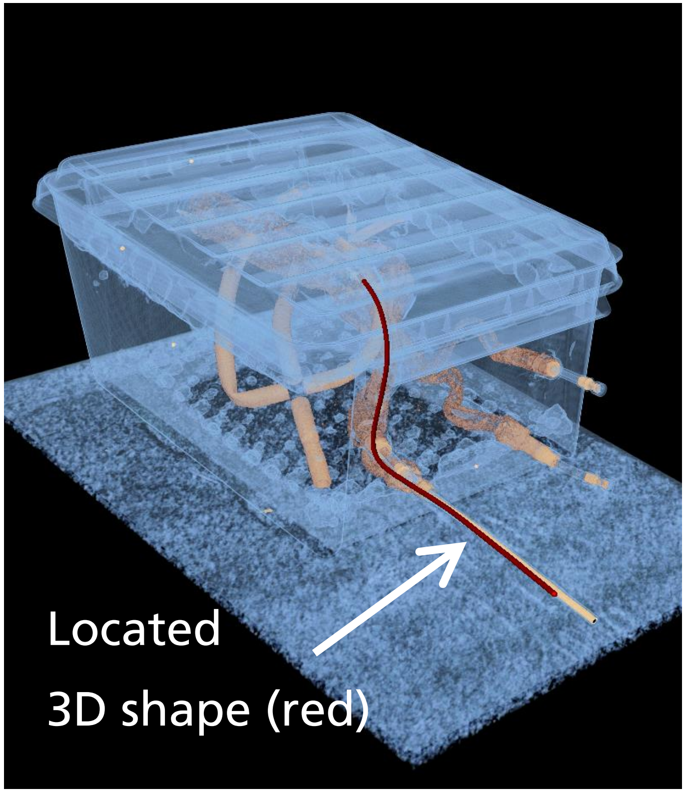


CT scan view



Motivation – clinical problem

Use case: vessel repair by implanting a stent graft

Current guidance method: 2D fluoroscopy with contrast agent

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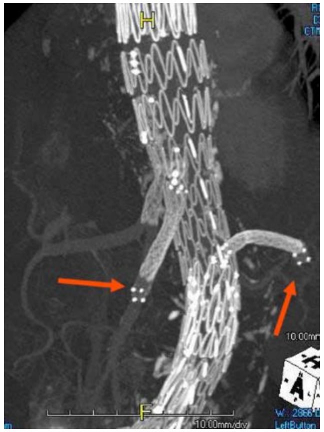

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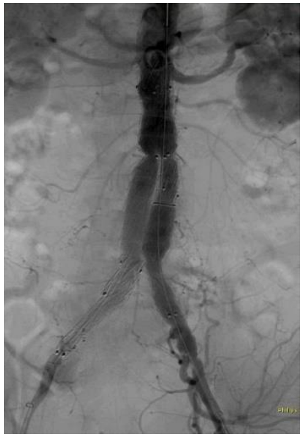

- Drawbacks:
  - Missing depth information
  - Radiation exposure of surgical team and patient (Rehani et al. 2006)
  - Kidney damaging contrast agent (Saratzis et al. 2015)

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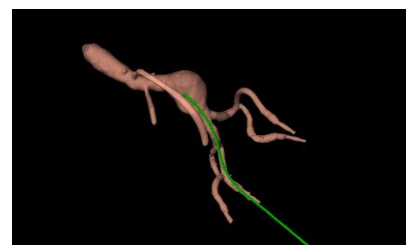
  - **Preoperative information**
    → Localization inside vessel system ✓



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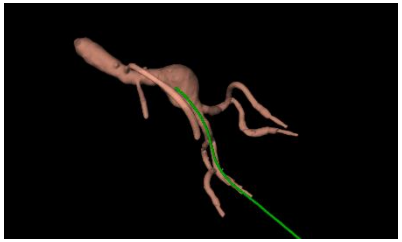

→ Shape + Location + Localization = 3D guidance

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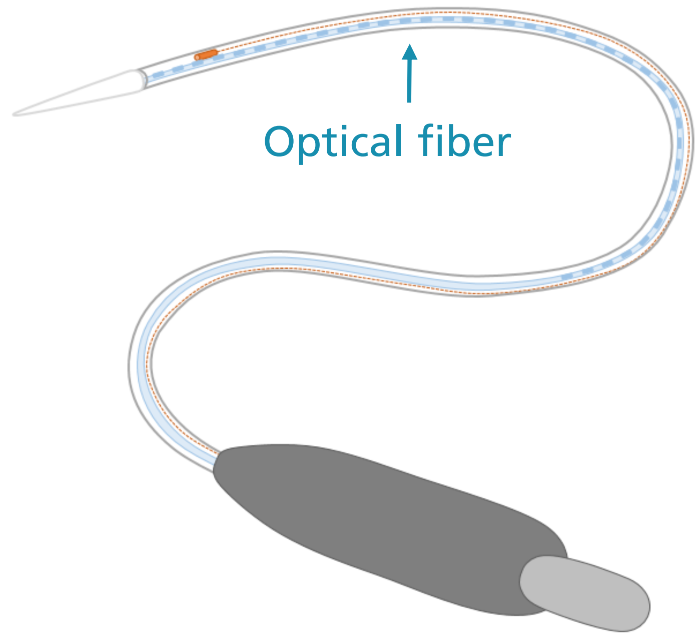
Stentgraft system

- Contains tracking system:
  - 1 Optical fiber

    → **Reconstructed shape of 38 cm as shape point list**



Stentgraft system

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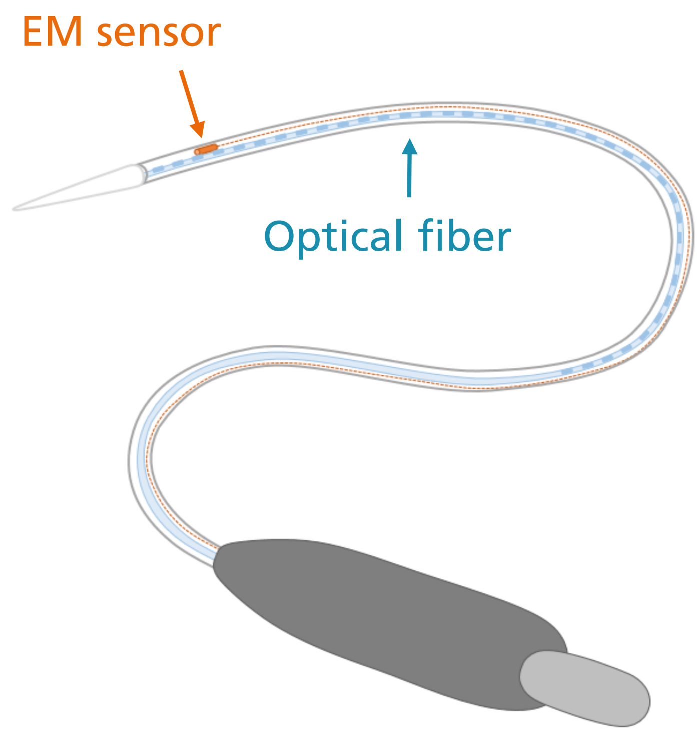
    → **Position and orientation information**



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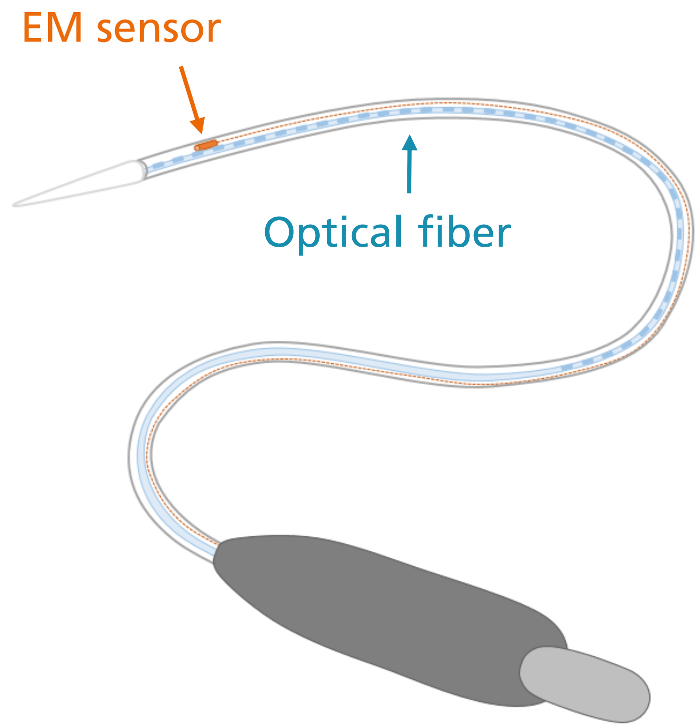
→ Accurate localization at the front part of the stentgraft system



Guidance method – shape localization

Given: Calibrated tracking information, preoperative vessel centerline & volume

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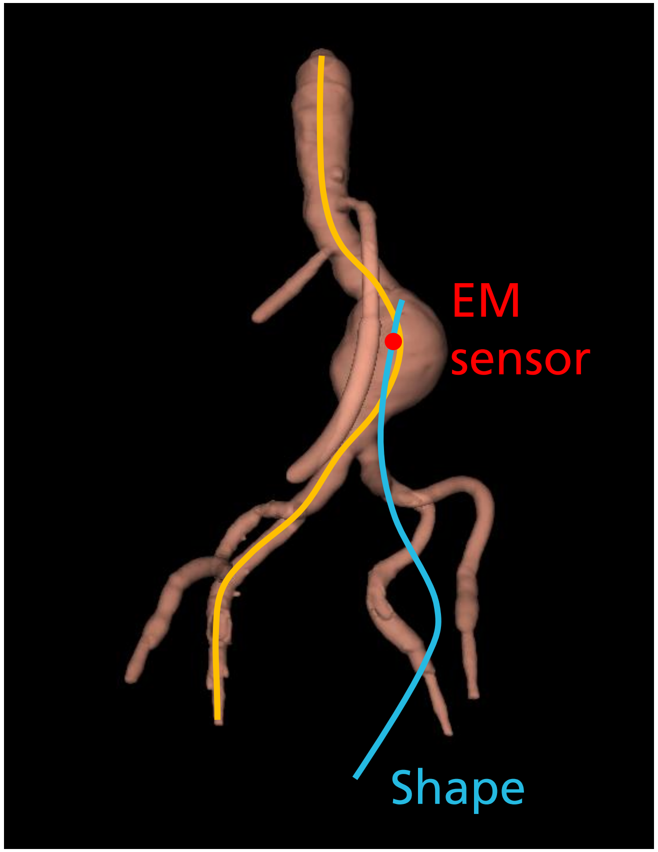
Method:

1. Transformation of shape into CT space

   → Shape located at EM sensor with correct direction



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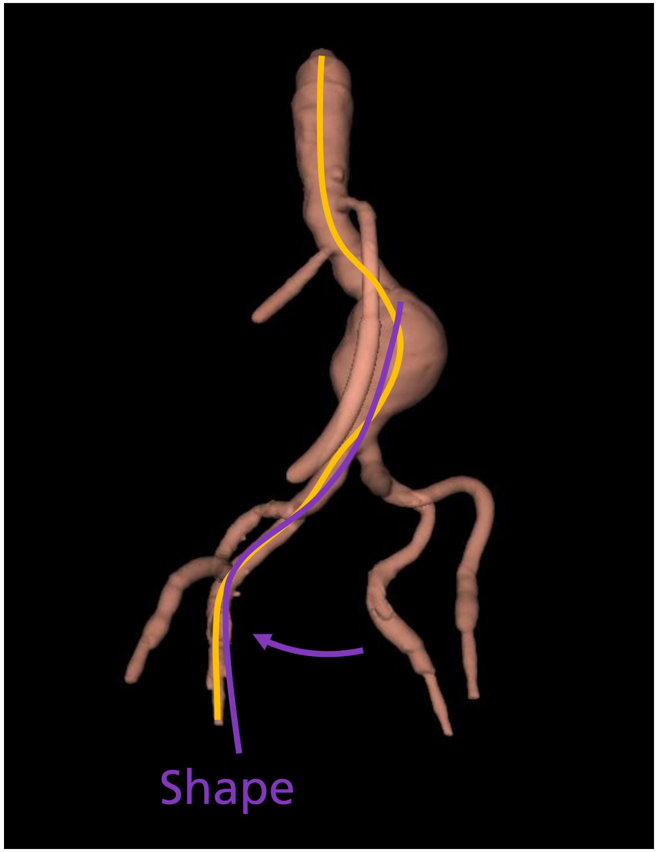
2. Shape prealignment with vessel centerline

   → **Shape rotated into vessel volume**



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3. Shape registration with vessel volume

   → **Shape located accurately in vessel volume**

Experiment – vessel phantom

- Insertion of the stentgraft system into a vessel phantom:

without agar-agar

with agar-agar

Experiment – setup

- Evaluation at five different insertion depths of the stentgraft system
- CBCT acquisition and the segmentations are used as ground truth
- Measures:

  average error: $e_{avg} = \frac{1}{m}\sum_{i=1}^{m} \left\| x_i - x_{i_{nearest}}^{gt} \right\|_2$

  maximum error: $e_{max} = \max\left(\left\| x_1 - x_{1_{nearest}}^{gt} \right\|_2, \dots, \left\| x_n - x_{n_{nearest}}^{gt} \right\|_2 \right)$

  tip error: $e_{tip} = \max\left(\left\| x_n - x_{n_{nearest}}^{gt} \right\|_2 \right)$

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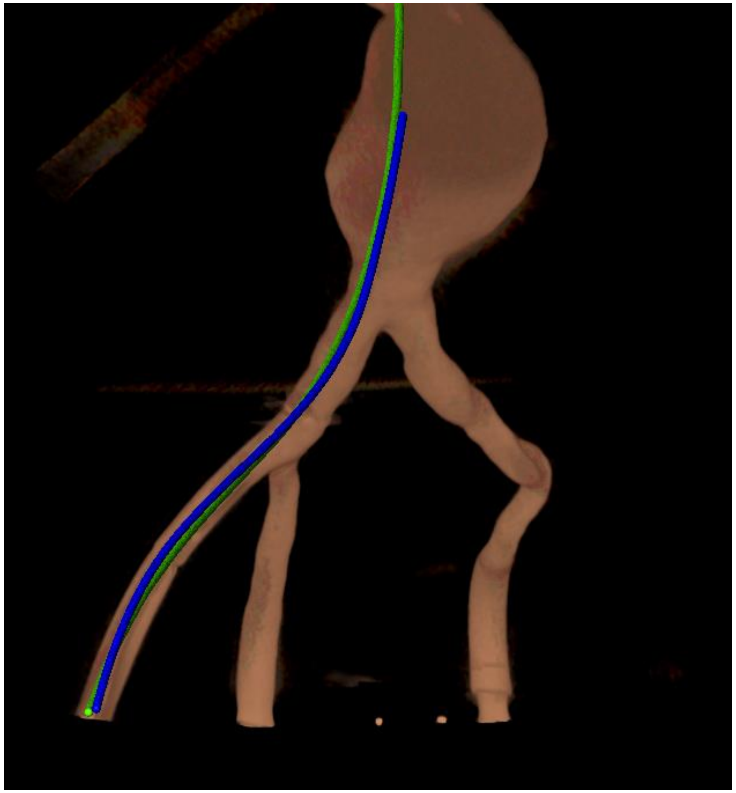
Experiment – setup

Results

First (left) and fourth (right) insertion depth

Ground Truth - Tracking based guidance

Results

- Measured errors (in mm) for five different insertion depths:

	Tracking based guidance			
Error	e_{avg}	e_{max}	e_{tip}	Evaluated length
1.	2.02	4.58	3.49	232.00
2.	1.81	4.44	4.44	225.00
3.	2.29	4.58	4.58	206.50
4.	2.30	3.21	3.21	185.50
5.	3.13	5.46	2.67	168.50

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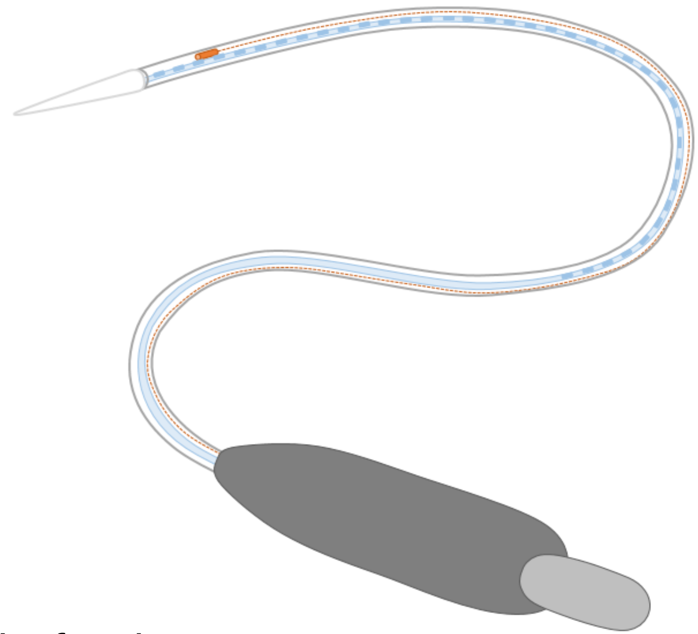
→ Promising results for clinical usage

Conclusion

- **A novel 3D guidance method based on an optical fiber, one EM sensor and preoperative data**

- Promising results for clinical usage

- Future work:
  - Evaluation in real-time
  - Development of a stentgraft guidance



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