

3D Catheter Guidance including Shape Sensing for Endovascular Navigation

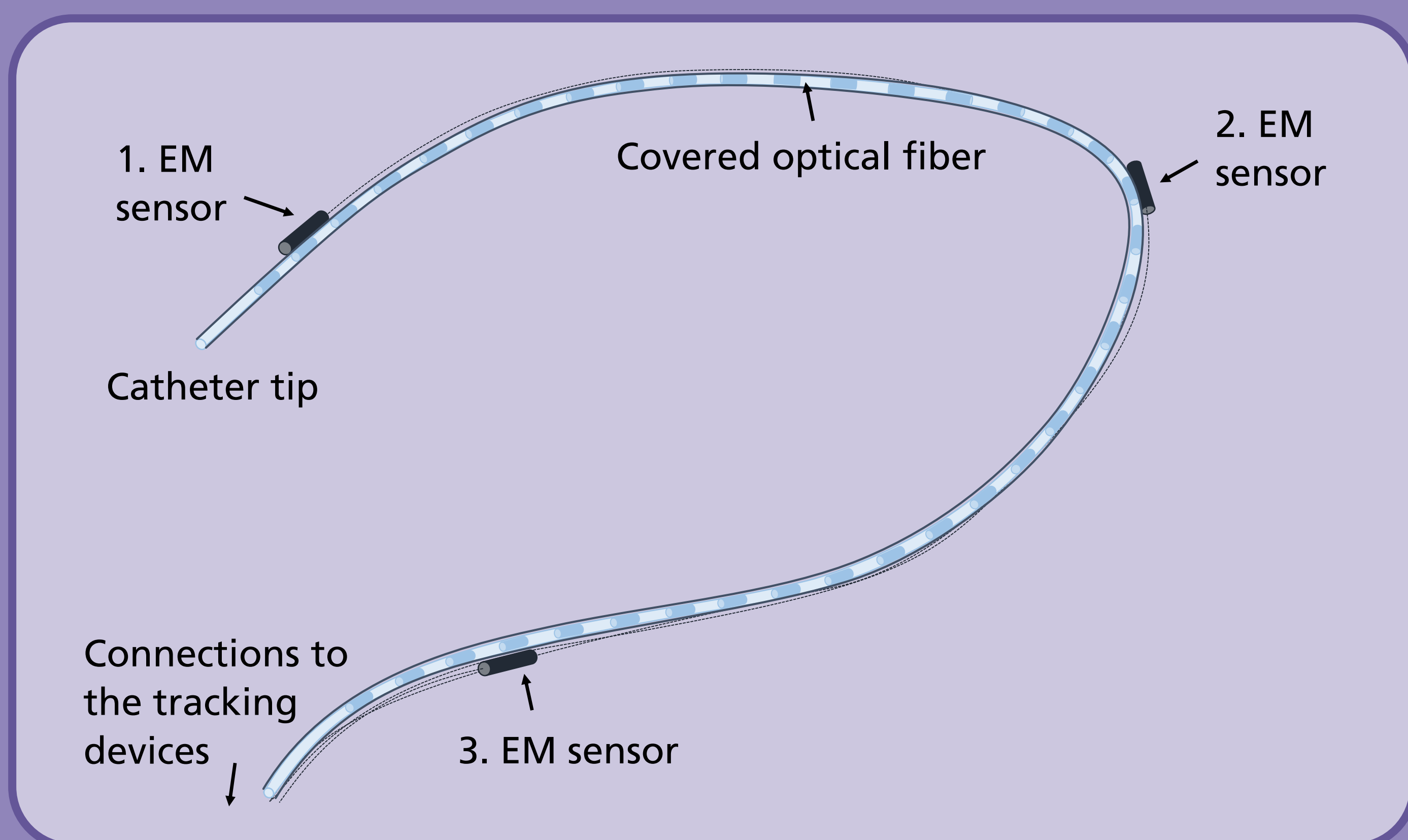
Sonja Jäckle, Verónica García-Vázquez, Felix von Haxthausen, Tim Eixmann, Malte Maria Sieren, Hinnerk Schulz-Hildebrandt, Gereon Hüttmann, Floris Ernst, Markus Kleemann, Torben Pätz

MOTIVATION

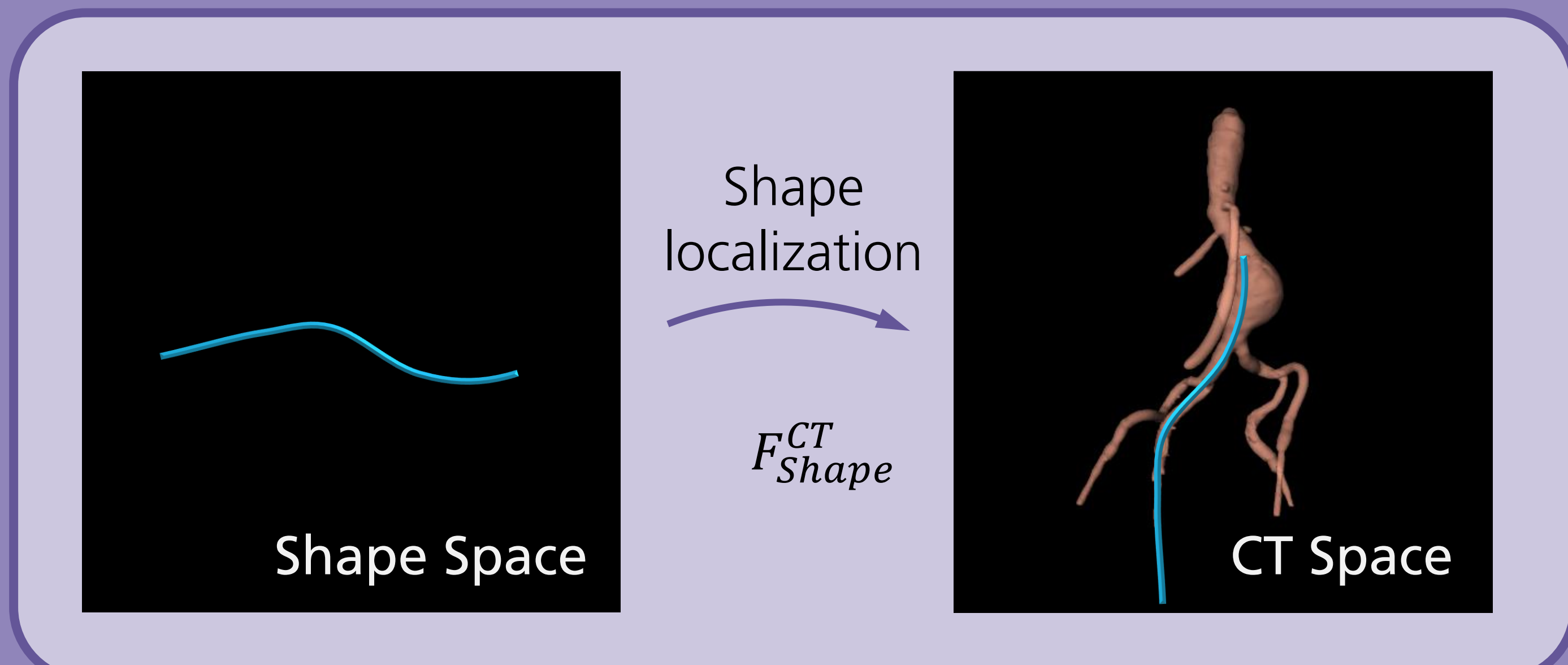
- State-of-the-art guidance: 2D fluoroscopy and administration of contrast agent
- Drawbacks: Use of X-ray, contrast agent is kidney damaging and the depth information is missing
- Novel approach: 3D catheter guidance by combining
 1. Fiber optical shape sensing → Shape
 2. Electromagnetic (EM) tracking → Position
 } Located Shape

METHOD

- Catheter prototype with integrated tracking systems:



- Given from the tracking systems:
 - Optical fiber → shape with 38 cm length as point list
 - 3 EM sensors → position and orientation of each EM sensor
- Calibration between optical fiber and EM sensors: A spatial relation between optical fiber and each EM sensor has to be determined once. For more details, see our SPIE paper [1].



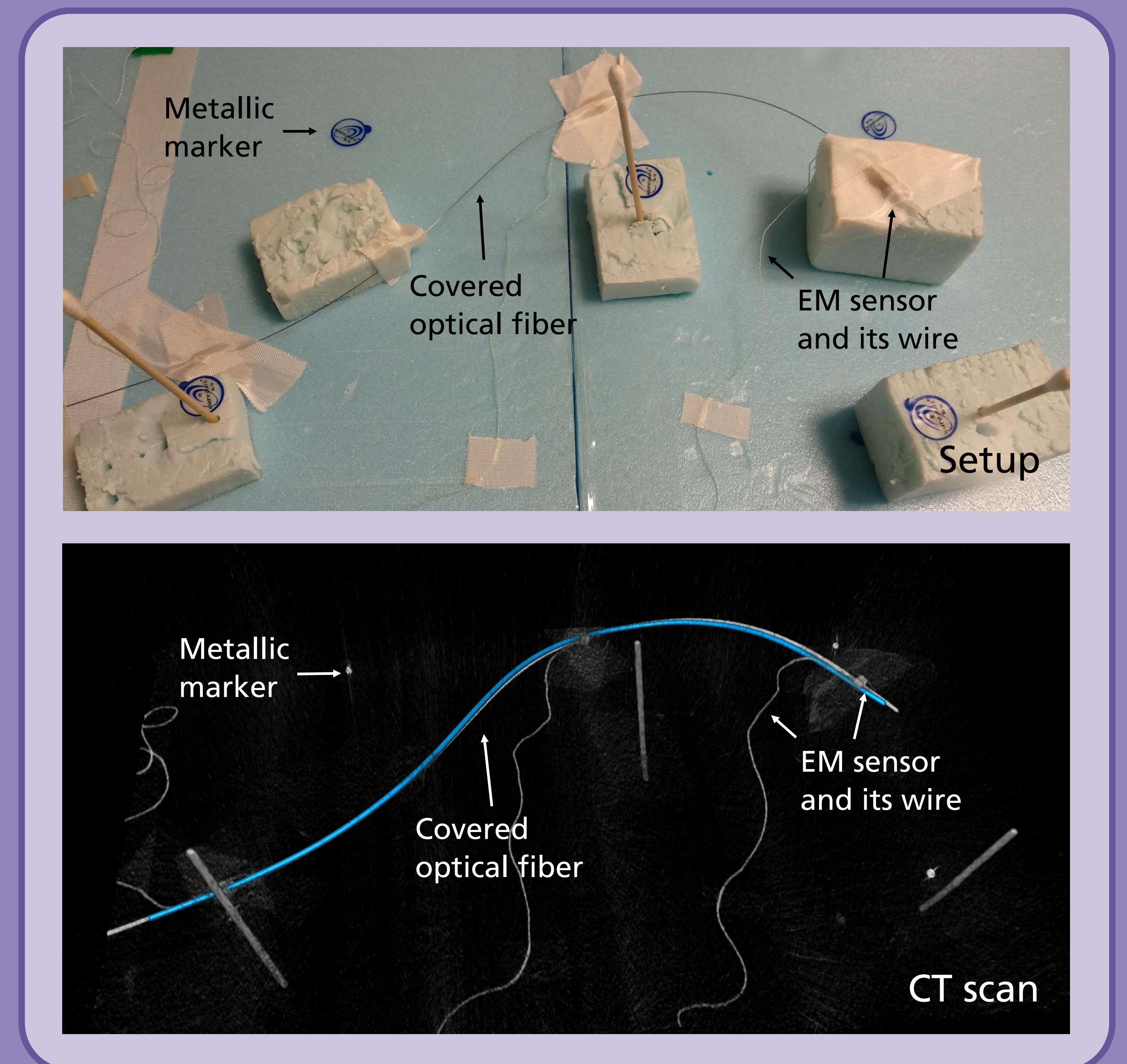
- Shape localization: Based on the results of the calibration step the transformation F_{Shape}^{CT} from shape into the CT space can be determined with a point based registration [2] and the shape can be located in the CT space.

REFERENCES

- [1] Jäckle et al., 3D Catheter Guidance including Shape Sensing for Endovascular Navigation, SPIE 2020.
- [2] Arun et al., Least-squares fitting of two 3-D point sets., IEEE Trans. Pattern Anal. Mach. Intell. 5, 698–700 (1987).

EVALUATION

- Five experiments: Bow, Curve, S-curve, 3D bow, 3D curve
- Setup: catheter prototype was fixed in a specific shape and five metallic markers were placed around it
- Ground truth: CT acquisition and 3D segmentation
- Example: 3D curve setup and CT scan with located shape (blue)



RESULTS

- Average e_{avg} and maximum e_{max} errors in mm:

Shape Error	Bow	Curve	S-Curve	3D Bow	3D Curve
e_{avg}	0.99	1.10	1.55	2.29	1.15
e_{max}	2.60	1.73	2.45	2.99	1.90

CONCLUSION

- Novel 3D guidance approach: Combination of fiber optical shape sensing and EM tracking
- Promising results:
 - Accuracy feasible for endovascular navigation in minimally-invasive procedures
- Future work:
 - Evaluation in a clinical setting
 - Methods for less than three EM sensors

CONTACT

Sonja Jäckle, sonja.jaeckle@mevis.fraunhofer.de

Preprint:

