Camera-based Guide Wire Tracking for a Hybrid Neurovascular Intervention Training System

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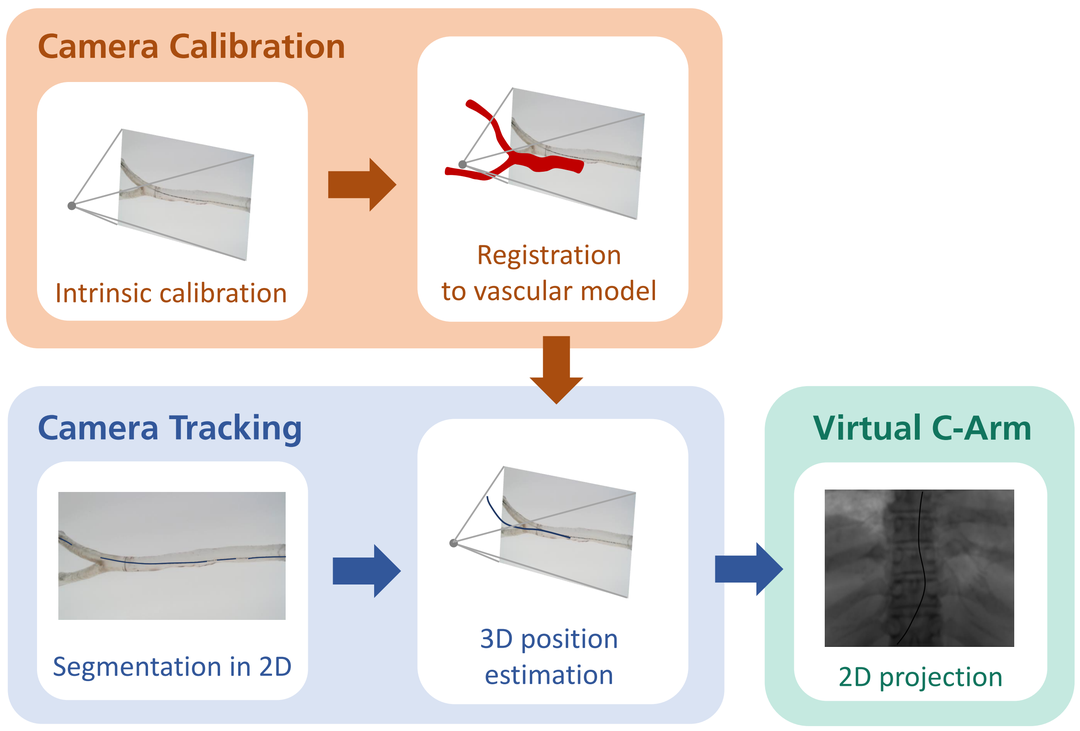
MOTIVATION

- For training of neurovascular interventions, fully virtual simulators – or – training systems based on phantoms and X-ray imaging are available
- Goal: a hybrid training system combining virtual and physical system
  - ✓ A realistic training environment
  - ✓ No need of imaging devices and infrastructure → flexible usage
  - ✓ X-ray free training

→ First step: Guide wire tracking based on camera images

METHOD



Camera Calibration:

- Intrinsic calibration: OpenCV-based [1] calibration of the camera itself to obtain its world matrix in relation to the focal point
- Registration to vascular model: Manual 2D-3D registration between the phantom visible in the camera image and the 3D vascular model

Camera Tracking:

- Segmentation in 2D: Threshold-based segmentation of the guide wire in the camera image and conversion into a point list
- 3D position estimation:
  1. Depth estimation based on the 3D vessel centerline and its 2D projection
  2. Sorting along the centerline
  3. Removal of false-positive points
  4. Spline-based interpolation

Virtual C-Arm:

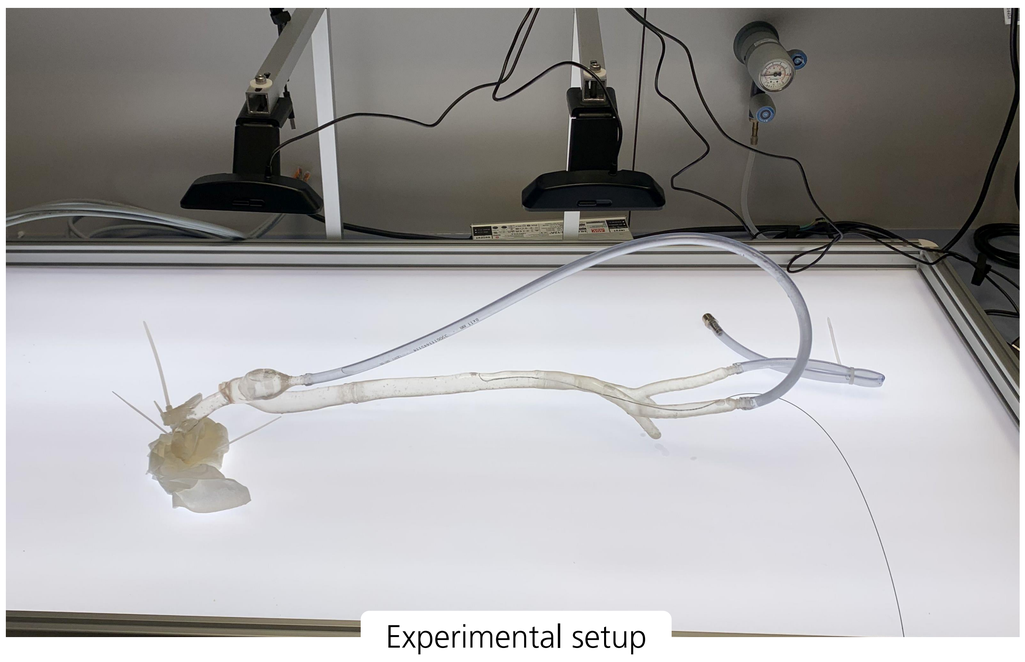
- Projection generation [2] based on the whole body computed tomography (CT) scan of the visible human project
- Vascular model is located at the anatomical correct position in the CT scan
- Projection of the 3D guide wire points into the 2D projection

REFERENCES

[1] Bradski G. The OpenCV Library. Dr. Dobb's Journal of Software Tools. 2000.

[2] Lange A, Heldmann S. Intensity-Based 2D-3D Registration Using Normalized Gradient Fields. Proc. BVM. Springer. 2020:163–8.

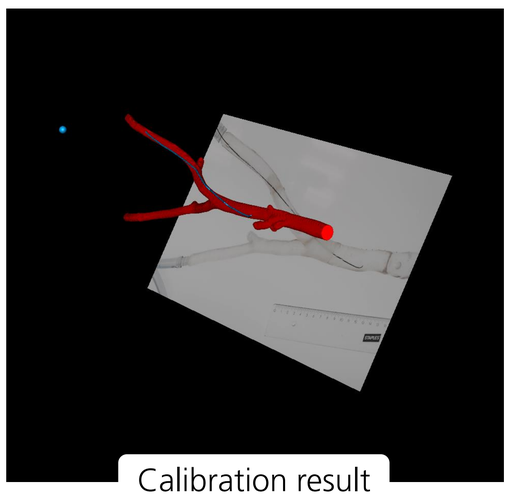
SETUP & EVALUATION



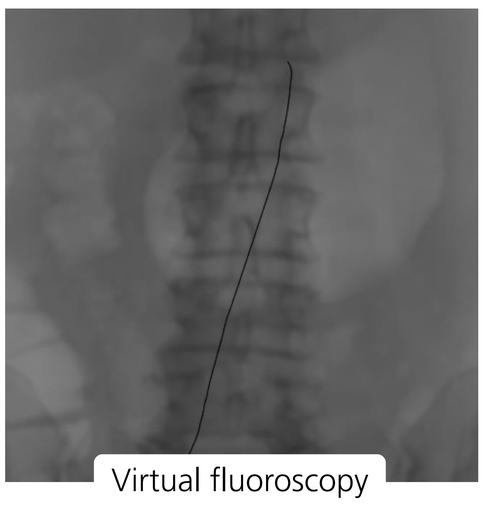
Experimental setup

- Light table with item profiles for camera fixation
- 3D printed aorta and iliac arteries based on a medical CT dataset
- Insertion of a guide wire with a J-shaped tip and image capture

RESULTS



Calibration result



Virtual fluoroscopy

- Camera calibration to the vascular model was successful (left image)
- The camera tracking and virtual C-Arm results in a realistic fluoroscopy image (right image)
- Our approach is real-time capable, see also the linked video

Video

s.fhg.de/STevNDemo

CONCLUSION

- First proof-of-concept for combining a physical with a virtual training system
- Next steps & future work:
  - ➢ Tracking setup for the whole vascular system
  - ➢ Integration of further instruments
  - ➢ Further evaluation of the system

Contact

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